ETD

EPRI
Electric Power
Research Institute

Keywords:
Demand-side management
Energy efficiency
Utility planning
Conservation
Marketing
Evaluation

EPRI TR-102021
Proceedings
March 1993

Proceedings: 6th National Demand-Side Management Conference

Making a Difference

March 24–26, 1993
Miami Beach, Florida

Sponsored by
Electric Power Research Institute
United States Department of Energy
Edison Electric Institute

Host Utility
Florida Power & Light Company

Founding Sponsor
Synergic Resources Corporation

serve as a vehicle to "sell" or promote new technologies and other energy related services to customers. For example, BG&E is currently assessing alternatives to maximize the use of its distribution substation facilities. First, the Company is studying the utilization of gas capacity to help defer or avoid the need for electric system reinforcement. Where gas is available, gas heat would be aggressively promoted thereby, minimizing cold load pick-up problems. Second, the Company is evaluating "dispersed" generation for summer critical periods. The utility will install a "generator" such as a natural gas fuel cell or packaged cogeneration systems to provide additional electricity.

The Company is also involved in operating natural gas vehicles. In 1992, the Company purchased 95 Chrysler vans with natural gas, converted additional vehicles, enlarged its existing refueling station and built four new ones. By 1996, BG&E expects to own 500 natural gas vehicles and maintain 6 refueling stations on BG&E's property and 3 public stations. Other products that are being evaluated for possible utility service offerings include, power quality service, operation and maintenance service for commercial customers, back-up generation which provides power quality and supplies power during outages. As the utility becomes more integrated into a customer's energy operations, more opportunities arise to promote energy related products to the customers. These products can be counted as new sources of revenues for the utility.

CONCLUSION

Competition is altering the traditional services the utility provides. In order to remain profitable, the utility must transform its business activity by efficiently utilizing its system assets, focusing its resources on meeting customer's energy needs and establishing partnerships with customers, and seeking new sources of revenue.

Demand-side management can play a major role in the utility's transition to a more competitive environment. Further, the combination utility is in a unique position to capitalize on DSM opportunities for both electric and gas. DSM programs can help effectively utilize system assets by implementing technologies which transfer load from one system to another where it benefits all rate payers; and by promoting high-efficient technologies. DSM program designs and implementation strategies can be tailored to meet specific customer needs and enhance satisfaction with the energy service provided. Finally, DSM initiatives can serve as a vehicle to sell other services and energy related products to minimize cost and expand non-traditional revenues. Examples include utilizing gas capacity to defer the need for electric reinforcement on the distribution system and to promote natural gas vehicles and power quality service.

GAS DSM—OPPORTUNITIES AND EXPERIENCES

Steven Nadel and Jennifer Jordan, ACEEE
Joseph Eto, Independent Consultant
Mark Kelley, Buildling Science Engineering

ABSTRACT

Increasingly, gas utilities and regulatory commissions are becoming interested in gas least-cost planning and demand-side management (DSM) programs. In order to help lay a foundation for these efforts, this paper reviews the results of a recent study on the economic potential for gas efficiency improvements in the residential and commercial sectors in the service areas of three New York gas utilities. In addition, a review of gas utility experience to date with gas DSM programs is presented. Based on these analyses, we conclude that there is a substantial cost-effective technical savings potential from gas efficiency measures and that experience with gas DSM programs shows that successful, cost-effective programs can be offered. However, gas DSM efforts are still in their infancy and much work remains to be done.

INTRODUCTION

During the 1980s, most demand-side management (DSM) activity has focused on electric utilities. These efforts have resulted in significant energy savings. Electric utility plans for the next decade indicate that savings should increase manyfold. However, in most states and provinces throughout the United States and Canada, gas utility DSM efforts are still in their infancy, being largely limited to studies, informational materials, energy audits, and an occasional pilot program. This situation may change soon as many state regulatory commissions are increasingly interested in gas DSM (Goldman and Hopkins, 1991).

In order to help lay the groundwork for these efforts, the American Council for an Energy-Efficient Economy, with support from the New York State Energy Research and Development Authority and the New York Gas Group (a consortium of New York State gas utilities), conducted a study to assess the economic potential for cost-effective gas DSM savings in New York State and to review gas DSM program experience to date.

serve as a vehicle to "sell" or promote new technologies and other energy related services to customers. For example, BG&E is currently assessing alternatives to maximize the use of its distribution substation facilities. First, the Company is studying the utilization of gas capacity to help defer or avoid the need for electric system reinforcement. Where gas is available, gas heat would be aggressively promoted thereby, minimizing cold load pick-up problems. Second, the Company is evaluating "dispersed" generation for summer critical periods. The utility will install a "generator" such as a natural gas fuel cell or packaged cogeneration systems to provide additional electricity.

The Company is also involved in operating natural gas vehicles. In 1992, the Company purchased 95 Chrysler vans with natural gas, converted additional vehicles, enlarged its existing refueling station and built four new ones. By 1996, BG&E expects to own 500 natural gas vehicles and maintain 6 refueling stations on BG&E's property and 3 public stations. Other products that are being evaluated for possible utility service offerings include, power quality service, operation and maintenance service for commercial customers, back-up generation which provides power quality and supplies power during outages. As the utility becomes more integrated into a customer's energy operations, more opportunities arise to promote energy related products to the customers. These products can be counted as new sources of revenues for the utility.

CONCLUSION

Competition is altering the traditional services the utility provides. In order to remain profitable, the utility must transform its business activity by efficiently utilizing its system assets, focusing its resources on meeting customer's energy needs and establishing partnerships with customers, and seeking new sources of revenue.

Demand-side management can play a major role in the utility's transition to a more competitive environment. Further, the combination utility is in a unique position to capitalize on DSM opportunities for both electric and gas. DSM programs can help effectively utilize system assets by implementing technologies which transfer load from one system to another where it benefits all rate payers; and by promoting high-efficient technologies. DSM program designs and implementation strategies can be tailored to meet specific customer needs and enhance satisfaction with the energy service provided. Finally, DSM initiatives can serve as a vehicle to sell other services and energy related products to minimize cost and expand non-traditional revenues. Examples include utilizing gas capacity to defer the need for electric reinforcement on the distribution system and to promote natural gas vehicles and power quality service.

GAS DSM—OPPORTUNITIES AND EXPERIENCES

Steven Nadel and Jennifer Jordan, ACEEE
Joseph Eto, Independent Consultant
Mark Kelley, Buildling Science Engineering

ABSTRACT

Increasingly, gas utilities and regulatory commissions are becoming interested in gas least-cost planning and demand-side management (DSM) programs. In order to help lay a foundation for these efforts, this paper reviews the results of a recent study on the economic potential for gas efficiency improvements in the residential and commercial sectors in the service areas of three New York gas utilities. In addition, a review of gas utility experience to date with gas DSM programs is presented. Based on these analyses, we conclude that there is a substantial cost-effective technical savings potential from gas efficiency measures and that experience with gas DSM programs shows that successful, cost-effective programs can be offered. However, gas DSM efforts are still in their infancy and much work remains to be done.

INTRODUCTION

During the 1980s, most demand-side management (DSM) activity has focused on electric utilities. These efforts have resulted in significant energy savings. Electric utility plans for the next decade indicate that savings should increase manyfold. However, in most states and provinces throughout the United States and Canada, gas utility DSM efforts are still in their infancy, being largely limited to studies, informational materials, energy audits, and an occasional pilot program. This situation may change soon as many state regulatory commissions are increasingly interested in gas DSM (Goldman and Hopkins, 1991).

In order to help lay the groundwork for these efforts, the American Council for an Energy-Efficient Economy, with support from the New York State Energy Research and Development Authority and the New York Gas Group (a consortium of New York State gas utilities), conducted a study to assess the economic potential for cost-effective gas DSM savings in New York State and to review gas DSM program experience to date.

ECONOMIC POTENTIAL ANALYSIS

Economic potential analysis looks at how much energy can be saved from a technical perspective at costs less than the marginal cost of the avoided energy source. However, an economic potential analysis considers only the costs of the measures themselves, and not the cost of programs designed to encourage customers to install the measures. An economic potential analysis also does not consider barriers to measure adoption, but rather assumes that all measures which are technically feasible and cost-effective will be adopted. Thus an economic potential analysis estimates the maximum amount of energy that could possibly be saved from DSM programs.

Methodology

In order to keep the scope of the project to manageable levels, the project steering committee elected to limit the analysis to the residential and commercial sectors, and to examine 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, a downstate urban area, and an upstate mixed urban/suburban/rural area, respectively.

To assess the economic potential for gas efficiency measures, computer models of several prototype buildings that are representative of the housing and commercial building stock in the LILCo, BUG, and NFG service areas were developed. Prototype models were calibrated to actual utility gas sales. For each prototype the costs and savings of individual efficiency measures were examined. Costs and savings were estimated through 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 in ways to capture the interactive effects between different measures, and thereby avoid double-counting of savings.

Measures were ranked in order of levelized cost per unit of gas saved and the cumulative savings calculated as one moved from the lowest to highest cost measures. Thus, for any given level of avoided cost, the economic savings potential can be identified. For these calculations, measure lives were estimated to approximate field conditions. Also, a 5% real discount rate was assumed. Sensitivity analyses were also conducted, to help bound the uncertainties in this analysis. These sensitivity analyses, which were modeled by raising or lowering the cost of the efficiency measures, can be used to represent variations in measure cost, savings or lifetime relative to the basecase assumptions. These sensitivity analyses also roughly model the impact of program administrative costs on the economic potential analysis (studies by Berry (1989) and Nadel (1990) estimate that these costs average approximately 25% of measure costs).

In interpreting the results, several caveats should be kept in mind. First, the results presented here are preliminary – the analysis is still being refined and some changes to the savings estimates are likely. Second, the data on existing energy use patterns and existing measure saturations which underlie this analysis are of questionable accuracy. The gas utilities covered in this study have only recently begun compiling this data and it will be several years before good data is available. With improved data, some changes in the savings potential estimates can be expected.

Residential DSM Potential

For the residential sector, the basecase estimate of cost-effective technical savings potential is 41–46% of gas sales for LILCo, 46–52% for BUG, and 44–52% for NFG (the range covers marginal gas costs of $2.50–4.00/DTh – a likely range based on preliminary estimates made by each of the utilities). The sensitivity cases expand the range of the cost-effective technical savings potential to 25–63%, with savings potentials varying by utility, sensitivity case, and marginal gas costs. These results are summarized in Table 1.

Table 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						
Basecase	41%	46%	46%	52%	44%	52%
Basecase costs + 25%	29	43	42	48	39	47
Basecase costs + 50%	25	41	34	47	27	44
Basecase costs – 25%	45	56	49	53	47	63

However, while the savings potential is quite large in each of the three service areas, these savings cannot be quickly achieved. In the basecase analysis, nearly 40 percent of the cost-effective savings are due to measures that are cost-effective only at the time existing equipment is replaced.

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 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; attic insulation in un-insulated and poorly insulated (e.g. R-5) homes; mainline steam vents and steam pipe insulation; and hot water demand control in multifamily buildings.

At the other extreme, there are a number of measures with levelized costs generally above the retail price of gas (e.g. approximately $7.00/DTh) that are unlikely to be cost-effective in most situations. Among these measures are: duct insulation (expensive to install on a retrofit basis); basement ceiling insulation; installing new heating and hot water systems on a retrofit basis (except in multifamily buildings); storm and replacement 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 levelized cost); and zoning of warm-air distribution systems. Measures not listed above generally fall in the mid-range of levelized costs; the cost-effectiveness of these measures is likely to depend on the particular application.

For this study to have meaning in the real world, the results of our analysis must compare favorably with the savings that have been achieved from the installation of packages of measures in real homes. Accordingly, savings estimates from this analysis were compared to two field studies -- a study on small single-family homes conducted in the NFG territory (Ternes et al., 1991) and on-going studies on steam-heated multifamily buildings conducted by the Center for Neighborhood Technology in Chicago (Katrakis, 1989). In general the results of these field studies tend to support our findings. However, additional field studies are needed before definitive conclusions can be drawn.

Commercial DSM Potential

For the Commercial sector, the basecase estimate of cost-effective technical savings potential is 14-16% of gas sales for LILCo, 14-18% for BUG, and 18-23% for NFG (based on marginal gas costs of $2.50-4.00/DTh. The sensitivity cases expand the range of the cost-effective technical savings potential to 12-24% in the commercial sector, with savings potentials varying by utility, sensitivity case, and marginal gas costs. These results are summarized in Table 2.

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); reduced hot water temperatures; and new high efficiency water heaters. 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.

REVIEW OF GAS DSM PROGRAM EXPERIENCE

For this research, over 40 utilities offering gas DSM programs were contacted. More than 100 gas DSM programs throughout the U.S. and Canada were identified, but many of these programs have only recently begun and could not supply data. Data were also not available for some of the older programs. In

Table 2. 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			
Basecase	14% 16%	14% 18%	18% 23%
Basecase costs + 25%	14 16	14 17	17 20
Basecase costs + 50%	14 15	12 16	13 18
Basecase costs – 25%	16 20	17 21	22 24

the end, program results were obtained from 17 utilities offering 72 conservation programs (52 residential and 19 commercial and industrial). Data collected from utilities included annual and cumulative data on the number of program participants and eligible customers, gas savings, and program expenditures. Data analysis focused on annual data, since little cumulative information was available.

To compare programs, three indices were used: participation rates, gas savings as a percent of retail gas sales, and levelized utility cost per therm saved. In calculating levelized program costs, a discount rate of 5% and a measure lifetime of ten years are assumed (except for equipment replacement and new construction programs, for which measure lifetimes of 15 and 20 years are assumed respectively).

Wisconsin utilities are responsible for more than one-third of the database programs, and California utilities are responsible for roughly one-fourth. The majority of the programs in the database (39) offer eligible customers an energy audit leading to recommendations and financial incentives for installation of gas-saving measures. The rest of the programs either offer incentives for upgrading water and space heating equipment or are new construction programs.

Since few aggressive gas conservation programs have been pursued to date, and since gas utilities offering conservation programs rarely track their program results closely, it must be emphasized that 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.

Results

The "typical" gas conservation program in the database (calculated using database averages, excluding a major outlier) was approved in 1988, has an annual participation rate of 3%, an average annual savings as a percent of retail gas sales for the relevant customer class of 0.1%, and an annual levelized utility cost of $2.70/DTh saved.

A "successful" program as defined in this study is a program that costs the utility less than $4.00/DTh, has a relatively high annual or cumulative rate (greater than 7%) and high annual or cumulative gas savings (greater than 0.3% of retail sales). There are 17 programs in the data base which meet the successful program criteria. For these 17 programs, the average annual participation rate is 9%, savings as a percent of sales are 0.3%, and levelized utility costs are $1.90/DTh. Average cumulative results are a 20% participation rate and 0.7% savings as a percent of sales. Successful programs have achieved approximately three times the participation rate and savings as the typical program at lower cost. Table 3 highlights some of the results from the database.

The present quality of the data from gas DSM programs prohibits any definitive statement of what types of programs have been successful and what types have not. However, some trends appear to be emerging from this analysis which are worth noting. Commercial and industrial programs in the database have achieved three times the savings of the residential programs at less than half the cost. Audit and installation programs appear to achieve greater overall savings at higher costs than other program types, whereas targeted equipment retrofit/replacement programs (without audits) appear to achieve higher participation rates. In order for gas DSM to have a significant impact on a utility's over-all gas load, both types of programs should be offered.

Approximately half of the programs analyzed, including nearly all of the programs with high participation rates and savings, have estimated levelized costs to the utility of less than $2.50/DTh. This indicates that programs can be designed that will be cost-effective to gas utilities (assuming long-run

Table 3. Average Annual Results of Gas DSM Programs in the Database.

	Participation Rate	Savings as % of Gas Sales	Levelized Utility Costs ($/therm)	Number of Programs
All Programs	3%	0.12%	2.70	71
Commercial & Industrial Programs	1%	0.21%	1.40	19
Residential Programs	3%	0.07%	3.40	52
"Successful" Programs	9%	0.34%	1.90	17

marginal gas costs are between $2.50-4.00/DTh), but that programs must be carefully designed so that program costs are kept within cost-effectiveness limits.

Traits which appear to be linked with successful programs include, among other things, user-friendly programs which require little time and paperwork on the part of the customer, use of trade allies in marketing, marketing approaches which emphasize direct customer contact by the utility, a diversity in types of incentives offered (including custom measure incentives), and significant financial incentives.

Finally, 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 implies that there is probably room for even the best gas demand-side management programs to improve.

CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis discussed above, we can conclude that there is a substantial cost-effective technical savings potential from gas efficiency measures. Furthermore, experience with gas DSM programs shows that successful, cost-effective programs can be offered. However, gas DSM efforts are still in their infancy and much work remains to be done. In order to advance these efforts gas utilities should expand the range of pilot DSM programs now being offered, in an effort to gain more program design and operation experience. In addition, gas utilities should prepare least-cost plans that develop integrated, long-range plans to meet future energy at the lowest cost to society. Such plans, should include extensive reliance on DSM to the extent these programs have a lower cost to society than traditional gas supply options. Finally, more research is needed in several areas including: gas savings potential in the industrial sector; data on gas use patterns and saturations at the end-use level (these provide a foundation for least-cost and program planning efforts) and additional field studies on the gas savings that can actually be achieved from comprehensive gas efficiency packages.

REFERENCES

Berry, Linda, 1989, *The Administrative Costs of Energy Conservation Programs*, ORNL/CON-294 (Oak Ridge, TN: Oak Ridge National Laboratory).

Goldman, C.A. and M.E. Hopkins, 1991, *Survey and Analysis of State Regulatory Activities on Least Cost Planning for Gas Utilities*, LBL-30353 (Berkeley, CA: Lawrence Berkeley Laboratory).

Katrakis, John, 1989, "Retrofitting Single-Pipe Steam Heating Systems," *Home Energy* 6(6), November/December, pp. 16–21.

Nadel, Steven, 1990, *Lessons Learned: A Review of Utility Experience with Conservation and Load Management Programs for Commercial and Industrial Customers*, Report 90-8 (Albany, NY: New York State Energy Research and Development Authority).

Nadel, S., J. Eto, M. Kelley, and J. Jordan, 1992, *Gas DSM and Fuel-Switching: Opportunities and Experiences (draft)* (Washington, DC: American Council for an Energy-Efficient Economy).

Ternes, M.P., P.S. Hu, L.S. Williams, and P.Goewey, 1991, *The National Fuel End-Use Efficiency Field Test: Energy Savings and Performance of an Improved Energy Conservation Measure Selection Technique* (Oak Ridge, TN: Oak Ridge National Laboratory).

THE ROLE OF GAS HEAT PUMPS IN ELECTRIC DSM

Mark Fulmer, Tellus Institute
Patrick Hughes, Oak Ridge National Laboratory

ABSTRACT

Natural gas-fired heat pumps (GHPs), an emerging technology, may offer environmental, economic, and energy benefits relative to standard and advanced space conditioning equipment now on the market. This paper describes an analysis of GHPs for residential space heating and cooling relative to major competing technologies under an Integrated Resource Planning (IRP) framework.

Our study models a hypothetical GHP rebate program using conditions typical of the Great Lakes region. The analysis is performed for a base scenario with sensitivity cases. In the base scenario, the GHP program is cost-effective according to the societal test, total resource cost test (TRC), and the participant test, but is not cost-effective according to the nonparticipant test. The sensitivity analyses indicate that the results for the TRC test are most sensitive to the season in which electric demand peaks and the technology against which the GHPs are competing, and are less sensitive to changes in the marginal costs of gas and electricity and changes in program administrative costs.