GAS-COOLING PROGRAM IMPACTS BENEFIT BOTH GAS AND ELECTRIC UTILITIES

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The Brooklyn Union Gas Company (BU) and ADM Associates have been conducting annual process and impact evaluations of the Gas Cooling Rebate (GCR) Program and the Gas-Engine Drive Rebate (GEDR) Program that BU has offered to its commercial and industrial (C&I) customers. This paper provides a description of the methodologies used to perform the impact evaluations and a summary of the results obtained.

Description of Programs Evaluated

Brooklyn Union has been offering its commercial and industrial customers two programs for gas-powered cooling (GPC) equipment.

- The Gas Cooling Rebate (GCR) Program began in mid-1992. Its objective was to encourage manufacturers to offer high-quality and reliable GPC equipment having capacity ratings in range of 3 to 200 tons. The program is targeted at air-conditioning (AC) for commercial-sector buildings of all types, where the GPC units can be directly substituted for electric air conditioning equipment.
- The Gas-Engine Drive Rebate (GEDR) Program began as a pilot program in mid-1994. Its objective was to encourage manufacturers to offer high-quality and reliable air-compressors, refrigeration compressors, and possibly other equipment that are driven by gas-fueled engines rather electric motors. The program is primarily targeted to industrial-sector facilities.

Brooklyn Union's GCR and GEDR Programs initially complemented similar DSM programs sponsored by Consolidated Edison Company (Con Edison), the utility that provides electricity to BU's customers. Until they were discontinued during the second-half of 1995, Con Edison's programs also offered rebates to customers who installed GPC and GED equipment. As a gas utility, BU benefits when customers install GPC equipment because the load from such equipment occurs during the off-peak period (i.e., the program helps to fill a "valley" in the annual load shape). As an electric utility, ConEd receives the usual benefits associated with DSM programs and receives additional benefit in that installations producing significant peak-period demand reductions can be targeted to geographic areas where the load distribution system is becoming overloaded, thereby avoiding or deferring the cost of an expensive up-grade.

The programs of both utilities included customer-education and financial-incentive components. The financial incentives took two forms: (1) rebates of a portion of the first-cost of the equipment (which tends to be high because the equipment is not as yet produced in large quantities, and contractors have little experience with installations); and (2) low-interest loans to qualifying customers.

Tables 1 and 2 provide summary information regarding participation in the GCR and GEDR Programs.

Impact Evaluation Objectives

The primary objectives in evaluating the GCR and GEDR Programs has been to estimate the net changes in annualized gas and electric energy requirements and in peak seasonal demands for electricity that could be expected as a direct result of offering the programs. The following impacts were estimated for all program participants:

1. Quantity of gas (Mcf) used to power GPC equipment installed under the two programs
2. Aggregate net reduction in electricity-use (MWh) that resulted from operation of this equipment
3. Aggregate net reduction in peak summer electricity demand (kW) that resulted from operation of this equipment

   Although some GPC equipment also provides space heating, only gas used by this equipment when operating in the cooling mode was estimated in the evaluation.

These impacts of the programs were estimated at two levels: "gross customer" and "net customer." "Gross Customer-Level Impacts" (GCLI) are those that are measurable (at least in principle) at the meters of customers. "Net Customer-Level Impacts" (NCLI) are the aggregates of the customer-level impacts that *are attributable to the DSM programs.* The NCLI values are usually different from the GCLI values, because some impacts may have occurred without the programs, because the GPC and GED equipment installed as a result of the programs may be used differently than the "alternative" equipment would have been used, or because some customers who were not official participants in the program may have installed the equipment promoted by the program as a result of the program.

Evaluation Methodology

Three methodologies to develop estimates of Gross Customer Level Impacts for the programs were used in the evaluation work: direct measurements of gas usage (through BU's load research study), regression analyses, and. engineering analyses. "Best" estimates of gas-usage impacts for GPC equipment were developed from the various types of analyses as appropriate. Ranked in order of preference, the approaches for arriving at "best" estimates of gas used by GPC equipment were as follows:

1. Load research data
2. Regression results for individual facility billing data
3. Facility-type regression results
4. Equipment-type regression results

For a subset of GCR program participants, BU collected data on gas usage for GPC equipment through its load-research study. For example, gas usage for GPC equipment at 15 facilities was monitored during the summer of 1995 as part of BU's load research activity. The results from this monitoring provided the information on gas consumption at 15-minute intervals (which could be summed to obtain hourly, weekly and seasonal values and which could be compared with the outdoor temperature data and billing readings). The load research data also provided a record of when the GPC equipment was in operation (which could be used to estimate total operating time per week and per season).

As a second line of analysis, regression analyses of gas usage data from BU's billing records for participants in the GCR and GEDR programs were used to develop estimates of the amount of gas used for air conditioning. Because some sites used gas for purposes other than space cooling (e.g., for space heating, cooking) and because billing data for all months of the year were included in the regression analyses, all regression models were intended to differentiate gas-usage for air-conditioning from gas usage for other end-uses.

The regression analysis of gas usage was based on the following equation:

$$G_t = B_o + B_1 HDH(Base)_t + B_2 CDH(Base)_t + B_3 AFTERDID_t + e_t$$

where:

G_t = average daily gas usage for a facility in month t (from billing data);

$HDH(Base)_t$ = a measure of heating degree hours to a specified base for facility in month t;

$CDH(Base)_t$ = a measure of cooling degree hours to a specified base for facility in month t;

$AFTERDID_t$ = a constructed dummy variable to represent the effects on gas usage from the installation of the GPC equipment. This variable is a product of three factors: (1) a dummy variable that was 1 for a facility in month t if that month was after the GPC equipment had been installed and that was 0 if month t was before the GPC equipment had been installed; (2) the total tonnage of GPC equipment installed at the facility; and (3) $CDH(Base)_{it}$.

B_{oi}, B_1, B_2, and B_3 are coefficients estimated through the regression analysis;

e_t is a statistical error term for unexplained variance in observed gas use for the facility in month t.

The estimated coefficient B_3 for the AFTERDID variable provided the information desired about the increase in gas usage that resulted from installing GPC equipment. This coefficient effectively measures the amount by which gas use changed in the months after GPC equipment was installed. In particular, a positive coefficient indicated that gas usage increased in the months following installation of GPC equipment. Multiplying this estimated coefficient by the tonnage installed and the number of cooling degree hours provides the estimate of gas usage.

Ambient weather conditions were represented in the regression models as *heating degree-hours* and *cooling degree-hours* calculated for different base temperatures. Degree-hours were used instead of degree-days because degree-hours provide a more representative measure of the effects of weather conditions. Depending on their energy-efficiency characteristics and the magnitudes of their solar and internal heat gains, buildings differ in the temperatures at which they begin to require heating and cooling. This fact was accounted for in the regressions analysis by performing regressions using degree-hours calculated for four different base temperatures: 50°F, 55°F, 60°F, and 65°F. With four measures of heating degree-hours and four measures of cooling degree-hours, there were sixteen possible combinations of the weather variables to investigate in the regression analysis.

Several different formulations of the regression analysis were explored to find the one that best "explained" the recorded gas-usage for a site after the GPC equipment was installed.

With a first regression formulation, gas-usage was analyzed at all facilities where GPC equipment with capacity ratings greater than 3 tons (i.e., in the 15–170-ton range) was installed. This model developed a separate estimate of average gas usage for each facility type (restaurant, office, retail, etc.). For these facility-type regressions, billing data for months both before and after the installation of the GPC units were used.

With the second regression formulation, billing data for all C&I facilities at which GPC equipment with capacity ratings greater than 3-tons were pooled on the basis of GPC-unit capacity-rating. The analysis then proceeded similarly to the facility-type analyses.

- With the third regression formulation, the billing data for facilities were pooled on the basis of a combination of facility type and GPC equipment type.
- With the fourth regression formulation, billing data was pooled for all C&I facilities at which 3-ton GPC equipment was installed.
- With the fifth regression formulation, billing data were analyzed for each facility separately, rather than "pooling" data for multiple facilities. Two separate analyses were performed. In the first, both pre- and post-installation data were included, while the second considered only post-installation data.

Because the data sets used for some of the regression analyses consisted of time-series billing data pooled across a cross-section sample of facilities, estimation procedures were used that took account of both the cross-sectional and time-series dimensions of the data. The regression analysis was accomplished by applying a least squares dummy variable (LSDV) covariance estimation procedure in which a binary dummy variable was created for each facility type in the subset and used in the regression analysis.

Estimates of the savings in electricity use that resulted from the use of GPC equipment were derived through an engineering analysis in which the "best estimates" of gas use for air conditioning were converted into estimates of the equivalent amount of electricity that would have been required. This engineering analysis to calculate electricity savings was based on the relative efficiencies of the GPC units and of the all-electric alternatives. The relative efficiencies vary significantly with the installed capacity of the cooling unit(s). The values used were based on the following assumptions:

- The alternative is a new unit of average efficiency.
- The same number of units and capacity/unit would have been installed.
- Units smaller than 40 tons have their condensers packaged with their compressors, and therefore the power required to drive the condenser fan must be included.

An estimate of net electric demand reduction was developed for each facility as the difference between (1) the peak demand that would have occurred if all-electric cooling equipment (DX or chiller) had been used and (2) the power demand of the electrical auxiliary devices associated with the GPC equipment. The peak demand that would have occurred if all-electric cooling equipment has been used is proportional to the capacity of the GPC equipment, but the kW/ton value varies with the size and type of cooling system.

Net customer-level impacts were estimated by applying gross-to-net adjustment factors that were developed from information obtained through telephone surveys of program participants and nonparticipants.

Estimated Gas Usage and kWh Savings From Use Of GPC Equipment

For sites that were in BU's load research study, gas usage for the GPC equipment was measured directly. These data were also used to validate the estimates of gas usage developed from the regression analysis. Comparison of the two estimates of gas usage for the load research sites that had GPC equipment showed close agreement for these facilities.

For 1995, GPC equipment installed by participants in BU's GCR Program was estimated to have used about 45,060 Mcf of gas. This implied gross electricity savings of about 3.8 Gwh. However, electricity use by auxiliary equipment for the GPC equipment amounted to 0.6 Gwh. Electricity savings net of auxiliary electricity use were therefore 3.2 Gwh.

Figure 1 shows the gas usage for GPC equipment in 1995 according to type of facility, while Figure 2 shows the associated electricity savings by type of facility. Health care and office facilities account for most of the gas usage and associated electricity savings.

Net Customer Level Impacts

Net Impacts of the program at the customer level are defined as the aggregate of the impacts experienced by the customers that are attributable to the program. In effect, Net Customer Level Impacts may differ from Gross Customer Level Impacts because of free-ridership, free-drivership, or takeback effects.

To assess these effects, participants in the GCR and GEDR Programs were asked a series of survey questions dealing with these possible effects. Responses to these questions were used to develop estimates of the magnitudes of the three effects. These estimates indicated a free-ridership effect of about 2.3%, with no free-drivership or takeback effects. The net-to-gross ratio therefore was 97.7%, indicating that most of the impacts were directly attributable to the programs.

Table 1. GCR Program Participation

Type of Facility	All Program Years		
	Number of Facilities	Number of GPC Units	Tonnage of GPC Units
Day Care	1	2	30
Education	2	10	170
Fitness Center	1	9	135
Grocery	1	1	35
Health Care	4	10	1,032
Industrial Processing	2	12	180
Laundry	1	1	15
Manufacturing	10	18	306
Office	11	24	1,793
Post Office	1	2	30
Recreation/Entertainment	4	7	435
Residence	4	7	21
Restaurant (Fast Food)	5	6	90
Restaurant (Full Service)	3	5	75
Retail	5	5	51
Shopping Center	1	2	72
Warehouse	1	1	15
Worship	4	10	300
Totals, GCR Program	61	132	4,785

Table 2. GEDR Program Participation

Type of Facility	All Program Years		
	Number of Facilities	Number of GPC Units	Horsepower of GED Units
Manufacturing	3	4	955

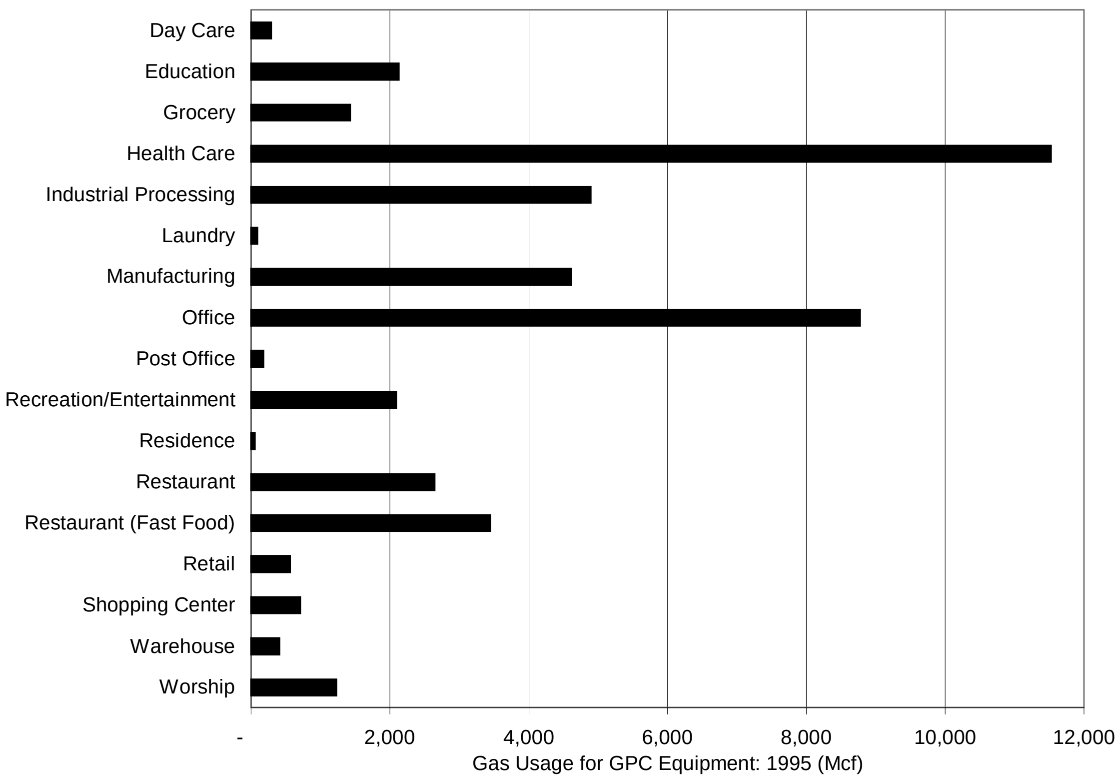

Figure 1. Gas Usage for GPC Equipment by Type of Facility: 1995

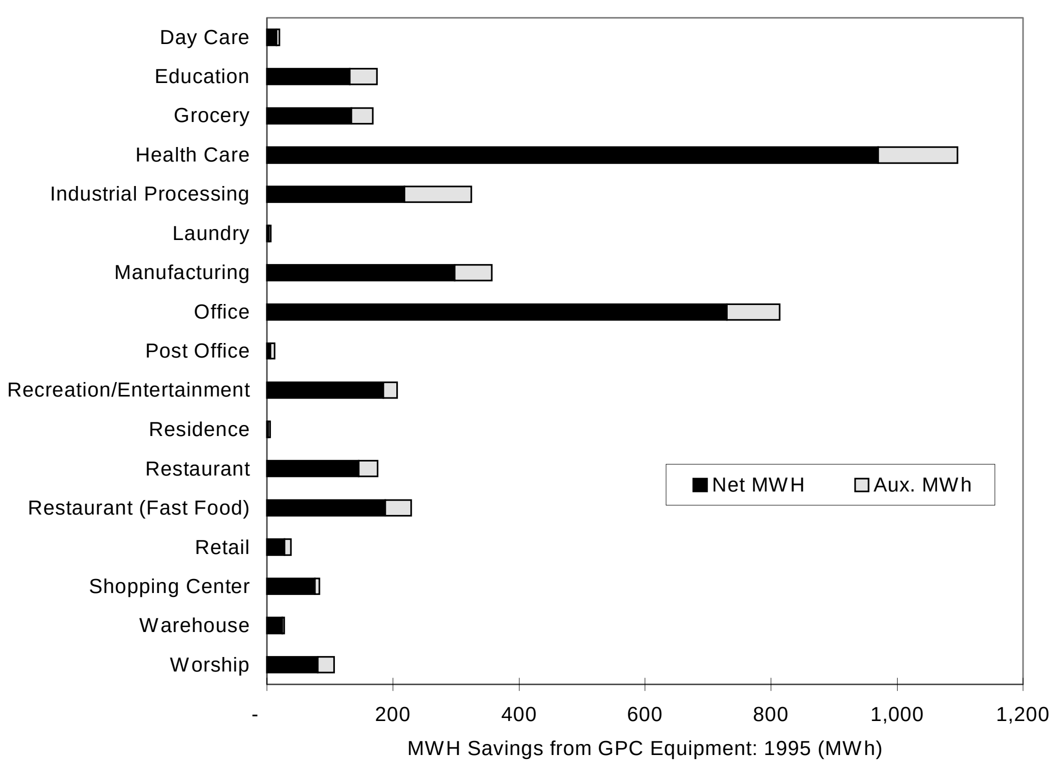

Figure 2. Electricity Savings from GPC Equipment: 1995