COMMERCIAL / INDUSTRIAL CHILLER MARKET DATABASE

Final Report

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Executive Summary

This report describes the development and potential uses of the Commercial / Industrial Chiller Market Database for Public Service Electric & Gas of New Jersey (PSE&G), performed by Pacific Energy Associates, Inc. (PEA).

The goal of this project was to develop and characterize a detailed list of chillers in PSE&G's service territory for the purpose of future program marketing. Telephone surveys were the primary means used to collect this information, which was gathered between October 1999 and June 2000. This list is a "near census" of chiller tonnage as the survey gathered chiller data from 598 customers and contacted almost 2,000. This likely encompassed nearly 70 percent of the total chiller tonnage in PSE&G's service territory. Additionally, contact information was collected for many of those partially responding.

To PEA's knowledge, this is a unique tool in the utility industry that can provide a way to focus on those customers with specific needs for improvements or upgrades to their chiller system. This database provides a means to directly target those with responsibility and interest in improving their chiller plant and specifically target customers with older chillers, which are more likely to need replacement. No broadbase advertising, program marketing, or lead generation is necessary – PSE&G can talk directly to individuals with a pitch for chiller efficiency.

The survey and the database characterize the chillers by size in tons, age, likely replacement schedule, and other key variables for program marketing purposes. In addition, characteristics of the individual who was responsible for making decisions regarding the facilities' chillers were determined. This included collecting information on budget cycle, their decision-making process, and the people involved.

A database was created to contain the results of the survey. This simple flat-file database is compatible with any future software since the database may be useful for subsequent programs. The database can be easily sorted and manipulated to create reports for targeting customers for future programs.

The survey used several methods to improve the rate of completed surveys. Business types not likely to use chillers were not contacted. Nor were accounts with low summer peak demand. An econometric analysis determined the probability of chiller presence, and this was used to focus on those most likely to have chillers. This method proved reliable in predicting the likelihood of chillers on the premises of individual customers. Altogether, over 3,000 contacts that would likely be nonproductive were avoided by use of these methods. The survey attempted to contact nearly every account that we believed had a reasonable chance of having a chiller.

All told, 69 percent of the customers who were judged to be appropriate targets responded. Of those, 34 percent had chillers. Of the customers with chillers, 65 percent provided complete information and 35 percent provided partial information.

The survey was less successful (only two responses) with large property management firms. PSE&G should recontact these firms when a program is available, and also clarify that it is significantly different than previous offerings.

Potential uses of the data include the following:

- Direct contact of customers with older chillers to market chiller replacement program (and advanced planning to secure funds and do analysis to optimize chiller systems).
- Use entire contact set for marketing other efficiency programs.
- Identify whether major SICs and building types have significant older chillers and obsolete refrigerants. If so, contract with a contractor with industry-specific expertise and market this consultant to the industry.

I. Introduction

This report describes the development of the Commercial / Industrial Chiller Market Database and describes potential uses for the chiller database.

The goal of this project was to develop and characterize a detailed list of chillers in PSE&G's service territory for the purpose of future program marketing. Telephone surveys were the primary means used to collect this information, which was gathered between October 1999 and June 2000. This list is a "near census" of chiller tonnage as the survey gathered chiller data from 598 customers by making contact with nearly 2,000. This likely encompassed nearly 70 percent of the total chiller tonnage in PSE&G's service territory.

The objective of the project was to locate and inventory "all" chillers greater than 100 tons in PSE&G's service territory and then to characterize the chillers by size, age, likely replacement schedule, and other key variables for program marketing purposes.

The responses were entered into a database, constructed as a Microsoft Excel flat file. Using simple database inquiries (sort) one can easily provide an ordinate list according to age, size, number of chillers, or by other fields. The final database provides a fully populated inventory of chillers in the PSE&G service territory. It includes this documentation to describe the methods used to create it, and recommendations for use of the database for marketing future chiller replacement programs.

The project used several methods to improve the rate of completed surveys. Business types not likely to use chillers were not contacted. Nor were accounts with low summer peak demand. An econometric analysis determined the probability of chiller presence, and this was used to focus on those most likely to have chillers. Altogether, over 3,000 contacts that would likely be nonproductive were avoided by use of these methods. The survey attempted to contact nearly every account that we believed had a reasonably chance of having a chiller.

II. Research Methodology

The research methodology describes the original data source and its manipulation, the survey approach, and initial data analysis and sorting methods used to achieve the project goals.

Data Sources
The primary data source for this project was the PSE&G Customer Information System (CIS) database of large commercial and industrial customers. It provided the basic information on the sample population. Substantial use has been made of data from the Energy Information Administration (EIA). These data provided insights into the relationships between the presence of chillers, energy use, and business type.

The PSE&G customer information service database has reliable information on the account for billing purposes and phone number. However, information on building size and SIC may not be accurate. The database contained the following fields:

- account number
- account name
- service address
- service city and zip
- building area code
- building phone number
- mailing address
- mailing city and zip code
- building contact name
- building contact title
- SIC code
- average monthly kWh
- account square footage
- minimum summer kW demand
- maximum winter kW demand

Database Manipulation
There are a total of just over 5,800 commercial and industrial accounts with winter or summer peak demand greater than 150 kW. In performing a "near census" of the chillers in this population a means was needed to survey only those accounts that have large chillers. Three approaches helped focus the survey towards accounts most likely to have chillers: For commercial accounts an econometric regression analysis was performed; for industrial accounts, SIC was analyzed for those most likely to have large cooling loads; and overall, the survey included the very largest accounts.

Commercial – Some commercial business types have a greater propensity to use chillers, and larger accounts (considered to be greater summer peak demand in kW) tend to use chillers more often. The relationship between summer and winter kW also indicates if an account would use a chiller. A comprehensive approach using multivariate regression analysis was performed. The results from this approach are the probability that a chiller exists for a particular account. The sample list then used a value that described chiller presence probability. The methodology used to determine this value is described below.

Industrial – We identified the industries more likely that others to use significant process or space cooling. Information from "Manufacturing Consumption of Energy-1994" compiled by EIA was used for the analysis. This analysis determined that Food, Chemicals, Rubber, Electronics, and Transportation were the top five industries for cooling use. The analysis used for this prioritization is described in detail below.

Customer Size – The sample selection methods above may exclude some of the largest PSE&G customers as measured by summer peak demand. These large customers may likely be industrial and have both process and space cooling chillers. Even if they might have been eliminated using the above methods, they were surveyed to include their chiller capacity and information.

The original database had 5,813 records. First, 426 accounts with less than 150 kW summer demand were deleted, leaving 5,387 records. In cases where winter peak demand (kW) equaled zero, we deemed it to be the same as summer peak demand. Those accounts with average monthly kWh of zero were also removed.

Additionally, there are several types of building that are very unlikely to have chillers. These included: warehouse (refrigerated and nonrefrigerated), grocery stores, and restaurants. These were also removed from the database leaving 4,577 accounts. The industrial accounts were also sorted by likelihood to have cooling according to industry type. One-quarter of the categories, including sand and gravel, paper, and asphalt were not assigned to surveyors because of their low likelihood to have chillers – a total of 190, leaving 4,387 accounts.

A chiller presence probability was calculated for each commercial account (see analysis below) and the value was attached to each record. For industrial accounts, a ranking according to the EIA analysis (see results below) was attached to each record. Each record was also assigned a unique four-digit ID code for survey tracking in lieu of account number. Surveyors were instructed to ignore those commercial accounts with low chiller probability. At the beginning of the surveying the cutoff were those accounts with probability of less than 15 percent, and at the end of the survey 30 percent was used.

After several months of survey activity an analysis of survey data collected to date was performed. This analysis looked at using summer kW as a predictor of chiller presence and of survey completion. Under consideration was improving survey productivity by eliminating accounts with less than a certain level of summer peak demand. From this analysis it was recommended that all accounts less than 500 kW summer peak demand that had not already been surveyed be set aside from the survey records used.

The SIC coding for nearly all accounts in the CIS database was reviewed and revised. About 550 records that had no SIC assignment had two-digit codes provided by inspection of the account name. Also reassigned for SIC were a number of hospitals, schools and a few other building types; about 150 were thus corrected. A more complete description of SIC revision is described below.

Survey Protocol

Telephone interviewing was the research approach used for this project. Individual database records were assigned to one of six chiller surveyors. Each of the surveyors had a understanding of building mechanical systems and with the organization typical of building maintenance and management. The surveyors were asked to contact building maintenance personnel by telephone to determine chiller presence and to collect a set of chiller and decision-making characteristics.

Introductions made to the maintenance person during the survey included a confidentiality statement and a brief description of the potential downstream benefit to the customer to engender their cooperation. We explained our interest in overall optimization by describing the difference between the "chiller" and the "chilled water system." This explanation was also useful in ascertaining that we were talking to a person knowledgeable about the chiller system.

With some customers, the chiller surveyor had to ensure that the customer had electric chillers and not steam or gas engine driven, absorption, or packaged direct expansion cooling. They also needed to eliminate those cases (mostly industrial) that used a cooling tower only. For this purpose the surveyors used a general definition of electric chillers. They described them as large machines that provide cold water for air conditioning or industrial process. They noted that they are usually water-cooled using a cooling tower, but are sometimes air-cooled. They further may have mentioned that chillers use a compressor and refrigerant to produce cold water, and are usually located in a mechanical room and not on the roof.

Surveyors used the telephone numbers provided in the Customer Information System database, and in some cases used Internet-based telephone directories to search for phone numbers. Upon contacting the customer, the person knowledgeable about building mechanical systems was identified. If that person could be reached and chillers were used in the building, the survey was completed and given a resolution of "COMPLETE." For other situations, there were nine possible chiller survey resolutions. These were:

ALT POWER – The account no longer purchases electricity from PSE&G.
BAD PHONE – No phone number can be identified, the phone number provided rings empty or yields a voice mail from which calls were not returned.
LOW PROB – Commercial account with chiller probability less than 15 or 30 percent.
LOW KW – Commercial/industrial account with less than 500 kW summer demand.
NO CHILLER – No chillers are used at the facility.
NO RESP – No response. Multiple telephone attempts (three to six calls) did not reach target person and calls were not returned.
NIB (not in business) – Plant is closing, moving out of service territory or already shut down.
REFUSED – Declined to be surveyed (variety of reasons).
YES CHILLER – Chiller(s) present, but survey not completed.

The resolutions of greatest interest to this project are COMPLETE, YES CHILLER, and NO CHILLER. These three resolutions are the only ones included in the database.

Large Property Management Firms
A somewhat different approach was taken with accounts that could be determined to be under the control of a large property management firm. The two dozen firms that own, control, or directly manage ten or more light industrial or office properties might have information on over 1,000 buildings. For these large property managers a high level approach was taken instead of attempting to contact maintenance personnel at individual buildings. This course was deemed prudent not only because it would be more efficient, but also because many of the telephone numbers and contacts for each building would lead again and again to the same individuals, causing an imposition.

The intention of the high level contacts at large property management firms was to find a single accountant, property manager, or facilities manager with overarching responsibility and knowledge of the buildings managed. Although we were successful in identifying and reaching that person in many cases, only two had sufficient interest to provide the information requested, and one of those property management firms had no chillers. For the purposes of marketing efficient chiller programs to these firms, it is recommended that they be contacted directly by PSE&G personnel once there is a program underway and a specific offer of assistance can be made. Based on comments from some property managers, it may be useful to note that the new program offers cash incentives and does not include the long-term verification protocols of the Standard Offer. The firms that were contacted included:

Gale & Wentworth
Hartz Mountain
Reckson Morris
SJP Properties
Lincoln Equities
Advance Group
Alfred Sanzari Enterprises
Brandywine Realty Trust
Mack-Cali Realty Group
M. Alfieri Co.
Murray Construction

Note that the Advance Group confirmed that their building stock had no chillers and for Hartz Mountain only about 10 percent of their buildings use chillers. Lincoln Equities has some public information on building systems (via the Internet) but it was not useful for this survey.

Customer Intelligence
During the nearly 2,000 conversations between PSE&G customers and the chiller surveyors, on occasion other issues came up for discussion. In about two dozen cases we forwarded this information or a request for service to PSE&G staff. Most of these involved impending changes to customer chiller systems, but others involved deregulation and utility competition, customer satisfaction issues, or simple requests for information.

Although this type of information collection was a minor sidebar to the activities of the chiller survey, it suggests that this type of blanket census of major customers may have value beyond the information collected. Many of these customers have no contact with PSE&G other than receiving a monthly bill. The maintenance staff typically contacted in this survey may never even see bills, nor meet or have a telephone conversation with PSE&G personnel on any level. Assessing customer satisfaction and providing an opportunity to correct impressions or occasionally even rectify significant misunderstandings could be an excellent tool for creating positive customer attitudes. Even a simple inquiry from or on behalf of the utility can engender a positive response from customers.

Estimation Method for Chiller Presence Probability
Some business types have a greater propensity to use chillers, and larger accounts (as sorted by summer peak kW demand) tend to use chillers more often. In addition, the relationship between summer and winter kW indicates if an account uses a chiller.

A comprehensive econometric approach using multivariate regression analysis was performed to include all three variables, business type, summer kW, and ratio of summer to winter kW. An initial analysis to determine the relationships between these variables and the presence of a chiller was determined based on nationwide Energy Information Administration (EIA) data. The resulting coefficients were then applied to the customer database. The results from this approach are a probability that a chiller exists for a particular account. A least-squares logit model was used for predicting the presence of chillers. This type of model allows the assignment of probabilities of presence of chiller based on the model results.

Step 1: Create the following demand and probability ratios from the EIA data:

Average kW	= average of Summer kW and Winter kW
Chiller Building Type Probability	= % Distribution of Chillers by Building Type (PBA)
Summer/ Winter Ratio Deviation	= abs([Summer kW / Winter kW] – 1.19)

The value 1.19 is the average summer/winter kW ratio. This variable the becomes the deviation from normal. The PBA is the Primary Business Activity. An equivalency to SIC code was established to relate these to the customer data. The table below shows the percent distribution of chillers as determined from the EIA data. Some Principal Building Activities were deemed very unlikely to have chillers. Thus these four were not included in the analysis: warehouse (refrigerated and nonrefrigerated), food sales, and restaurants.

Table 1 – PBA Chiller Distribution (per EIA data)

Principal Building Activity	Percent of Buildings with Chiller
Healthcare (inpatient)	65%
Office/Professional	39%
Public Order & Safety	33%
Enclosed Shopping Mall	31%
Laboratory	31%
Lodging	28%
Education	26%
Other	25%
Healthcare (outpatient)	24%
Public Assembly	23%
Vacant	20%
Nursing home	17%
Services	10%
Religious worship	10%
Restaurants	6%
Warehouse (nonrefrigerated)	5%
Strip Shopping	4%
Retail (not mall)	2%
Food Sales	0%
Warehouse (refrigerated)	0%

Step 2: Develop an econometric logit model to predict presence of a chiller on EIA sample.

Table 2 below presents the results of the analysis. All independent variables included in the model are significant at the 99 percent level of confidence. All signs in the model are of the correct sign: higher average kW increases the probability of having a chiller, a PBA that is more likely to have a chiller is assigned a higher probability of having a chiller, and a summer/winter ratio that deviates too much from the mean is less likely to have a chiller.

Table 2 – Logit Model Results

Independent Variable	Estimate	Error	Probability Estimate is not 0
Intercept	-2.3587	0.1434	0.0001
Average kW	0.00578	0.000056	0.0001
Chiller PBA Probability	4.0957	0.3954	0.0001
Summer/Winter Ratio Deviation	-1.0942	0.2661	0.0001

Step 3: Determine how well the model predicts presence of chiller.

Tables 3 and 4 show how likely the model is correct. Table 3 compares the prediction against EIA data and Table 4 from the actual survey data of commercial buildings. From these tables we can see that the model can provide fairly accurate results for predicting the presence of a chiller.

Table 3 – Logit Model Performance (with EIA data)

Logit Probability Range	Percent Correct Predictions of Chiller
0%-10%	3%
10%-20%	11%
20%-30%	28%
30%-40%	37%
40%-50%	58%
50%-60%	68%
60%-70%	72%
70%-80%	77%
80%-90%	73%
90%-100%	88%

Table 4 – Logit Model Performance (with actual data)

Predicted Probability Range	Percent Correct Predictions of Chiller
0%-20%	18%
20%-40%	32%
40%-60%	43%
60%-80%	68%
80%-100%	66%

Step 4: Probabilities for each account in the CIS data are calculated from the model.

The model predicted results from Step 2 was applied to each building in the customer data. The formula for the model prediction is:

$$x = -2.3587 + 0.000578 * AveragekW + 4.0957 * ChillerPBA\,\mathrm{Pr}obability - 1.0942 * SummerW\,\mathrm{int}erDeviation$$

Step 5: The probability that the building has a chiller is computed as follows:

$$P = \frac{\exp(x)}{(1+\exp(x))}$$

Industrial Account Priorities

In analyzing the PSE&G customer database and industry-wide data compiled by the Energy Information Administration, we identified a number of factors that supported the inclusion of industrial accounts in the chiller survey. According to PEA's observations of a number of utility efforts, chiller conversion/replacement programs have had notable successes with industrial customers.

In the table below, accounts in the customer database were sorted into industrial (SIC 0 to 39) and commercial/institutional (SIC 40 to 99). Those accounts without an assigned SIC were not included in this analysis. The table below shows that while industrial accounts are only one-third of the total number of accounts, the peak summer demands for industrial accounts are about one-third higher than for commercial accounts. For accounts above 5 or 10 MW summer demand, there are more industrial than commercial accounts. These results indicate that industrial customers are a significant portion of PSE&G's load and are important for inclusion in the survey. The next step, described below, describes which industrial customers are more likely to have chillers.

Table 5 – Industrial vs. Commercial Account Summary

	Industrial	Commercial	Percent Difference
Number of Accounts	1,569	3,600	-56%
Number of Accounts >150 kW	1,460	3,388	-57%
Average kW Demand (all accounts)	824	620	33%
Average kW Demand (accounts >150 kW)	886	657	35%
Accounts with demand >10 MW	11	6	83%
Accounts with demand >5 MW	38	33	15%

It is understood that the majority of end-use loads in industrial facilities are process related. However, nearly all accounts that are SIC coded as "industry" will also feature office, administration, laboratory, engineering and some fabrication buildings that will have space cooling. Chillers will sometimes provide cooling in these buildings. Our assumption is that the very largest accounts across both industrial and commercial account types may have chillers as part of a large facility and are thus worthy of inclusion in the survey.

We have also identified the industries more likely that others to use significant process or space cooling. Information from "Manufacturing Consumption of Energy-1994" compiled by Energy Information Administration (EIA) was analyzed for this purpose. The document describes industrial end-uses by SIC code, in particular process cooling and HVAC.

Manufacturing Consumption of Energy 1994 provides estimates on energy consumption in the manufacturing sector of the U.S. economy. The estimates are based on data from the 1994 Manufacturing Energy Consumption Survey (MECS). The MECS, administered by the Energy Information Administration (EIA), is the most comprehensive source of national-level data on energy-related information about the manufacturing industries. The amount of energy an establishment uses is collected for all of its operations and not solely for the amount of energy used in manufacturing its product.

The electrical energy used for process cooling, HVAC (including space cooling) was totaled and percentages of the total were determined. These values were then ranked into the top seven for the total of both process and HVAC end-uses. The table below shows the results.

This analysis determined that Food, Chemicals, Rubber, Electronics, Transportation, Textiles, and Industrial Machinery were the top seven industries for cooling use. Other industries likely use chillers of respectable size for space cooling of their laboratories, offices, and fabrication facilities as well as process. The survey focused first on these seven industries.

Table 6 – Industrial Cooling Prioritization

SIC	Description	Total Process & HVAC Elec.	Percent Total	Rank
20	**Food**	**18,277**	**18%**	**1**
21	Tobacco	238	0%	
22	**Textiles**	**6,557**	**6%**	**6**
23	Apparel	1,844	2%	
24	Lumber	1,031	1%	
25	Furniture	897	1%	
26	Paper	4,023	4%	
27	Printing	4,164	4%	
28	**Chemicals**	**15,697**	**15%**	**2**
29	Petroleum	2,941	3%	
30	**Rubber**	**6,753**	**6%**	**5**
31	Leather	119	0%	
32	Stone	2,518	2%	
33	Primary Metals	5,513	5%	
34	Fab Metals	4,164	4%	
35	**Industrial Mach.**	**6,449**	**6%**	**7**
36	**Electronics**	**9,161**	**9%**	**3**
37	**Transportation**	**8,518**	**8%**	**4**
38	Instruments	4,164	4%	
39	Misc. Mfr.	1,216	1%	
TOTALS		104,244	100%	

Source and Units - EIA Manufacturing Consumption of Energy 1994. Energy is Net Electricity, million kWh.

SIC Reassignments

Building type and business activity drive the chiller survey prioritization described above. Correct SIC codes were thus necessary to a successful project. Some of the SIC number provided in the Customer Information System database were incorrect and were recoded as described below. Correct SIC codes also served as criteria for selecting a reasonable sample size.

In the 5,800 accounts provided in the Customer Information System database, about 550 were found with no SIC assigned. These were coded by inspection of the account name. Also corrected were a relatively small number (about 150) of important categories including hospitals and schools also by inspection of the account name. In addition to hospitals and schools, some accounts like the following were found and corrected:

Garden State Prison coded as 5193, Flowers and Nursery Stock
Union County Jail coded as 5194, Tobacco Products
Somerset Tire Service coded as 6022, State Commercial Bank
King's Supermarket coded as 8299, Schools and Educational Services.

Table 7 below shows some examples of the potential variation in coding across the same account name. It's possible that the policies of PSE&G have varied over time insofar as assigning a SIC code specific to the business as a whole vs. to the activities at a particular site. From our work with other utilities we've seen similar problems with SIC classification. Still, we might expect that Merrill Lynch and Passaic Valley Water should all be coded the same, even if Liz Claiborne was not. (Note that spelling errors were not corrected.)

Table 7 – SIC Recoding Examples

Account	Name	SIC	SIC Definition
2152614607	LIZ CLAIBORNE	5651	Family Clothing Stores
4106607514	LIZ CLAIBORNE	4225	General Warehousing and Storage
2152614518	LIZ CLAIBORNE	2331	Women's, Misses', and Juniors' Blouses and Shirts
2192940734	LIZ CLAIBORNE	2387	Apparel Belts
6261206252	LIZ CLAIBORNE	2331	Women's, Misses', and Juniors' Blouses and Shirts
6261233128	LIZ CLAIBORNE COSMETICS	4225	General Warehousing and Storage
2194901914	LIZ CLAYBORNE	5621	Women's Clothing Stores
	NOT USED	2844	Perfumes, Cosmetics, and Other Toilet Preparations
2194423214	MERRILL LYNCH	6221	Commodity Contracts Brokers and Dealers
6220421310	MERRILL LYNCH	6311	Life Insurance
5233740419	MERRILL LYNCH & CO	6211	Security Brokers, Dealers, and Flotation Companies
5247414713	MERRILL LYNCH & CO	7331	Direct Mail Advertising Services
6249410619	MERRILL LYNCH & CO	6311	Life Insurance
6219099168	MERRILL LYNCH & CO	6153	Short-Term Business Credit Institutions, Ex. Agricultural
5233740311	MERRILL LYNCH CO	6211	Security Brokers, Dealers, and Flotation Companies
3157643355	PASSAIC VALLEY WATER	9511	Air and Water Resource and Solid Waste Management
3176001258	PASSAIC VALLEY WATER	5074	Plumbing and Heating Equip. and Supplies (Hydronics)
3104896542	PASSAIC VALLEY WATER	9631	Regulation and Admin. of Communications, Electric, Gas
3123895440	PASSAIC VALLEY WATER COM	7349	Building Cleaning and Maintenance Services, NEC
3184995348	PASSIAC VALLEY WATER COM	9621	Regulations and Admin. of Transportation Programs
	NOT USED	4941	Water Supply

Total Chiller Capacity

An estimate was made of the total chiller capacity in PSE&G service territory, based on PEA's experience with other utilities and data from this survey. The chiller capacity was imputed from average chiller size by SIC from the completed surveys. The saturation of chillers was taken from the relationship of COMPLETED and YES CHILLER surveys to NO CHILLER surveys, again by SIC. Then PSE&G accounts were taken from the full database and their individual SIC codes were used to estimate the total chiller capacity each SIC code group. The total estimated chiller capacity in PSE&G service territory is 580,600 tons. Only SIC with non-zero results are shown in the table. The average chiller saturation was used where calculated values were zero or greater than 100 percent because of to insufficient data.

Note that the chiller saturation values of Table 1 and Table 8 are different. Table 1 values are from national EIA data and describe buildings only by type of commercial building activity (PBA). Information from EIA could have been used to determine total chiller tonnage for PSE&G territory, but more accurate information from this survey was used instead. Table 8 values are from this survey, and provided chiller saturation by business type or SIC for all industrial and commercial buildings.

Table 8 – Total PSE&G Chiller Capacity Estimation

2-digit SIC Code	SIC Classification	Number of Accounts	Ave. Chiller Cap, Tons	Chiller Saturation, %	Total Chiller Tons
20	Food	132	350	39%	18,010
22	Textiles	59	360	3%	574
23	Apparel	32	240	52%	3,994
24	Lumber	6	240	52%	749
25	Furniture	13	240	52%	1,622
26	Paper	109	240	33%	8,720
27	Printing	127	170	27%	5,888
28	Chemicals	285	450	52%	66,690
29	Petroleum	34	240	52%	4,243
30	Rubber	168	30	52%	2,621
31	Leather	8	240	52%	998
32	Stone	47	240	30%	3,384
33	Primary Metals	88	70	15%	909
34	Fabricated Metals	103	120	40%	4,944
35	Industrial Machinery	71	40	17%	473
36	Electronics	76	240	11%	1,940
37	Transportation	15	240	9%	327
38	Instruments	52	180	65%	6,056
39	Misc. Manufacturing	34	240	52%	4,243
40	Railroad	2	240	52%	250
41	Local Rail	17	240	50%	2,040
42	Trucking	107	240	14%	3,669
43	USPS	13	240	33%	1,040
44	Water Transport	21	240	25%	1,260
45	Air Transport	16	240	75%	2,880
46	Pipelines	6	240	52%	749
47	Transport Services	30	240	9%	655
48	Communications	85	240	52%	10,608
49	Utilities	94	360	21%	7,083
53	Retail General	155	360	52%	29,016
56	Retail Apparel	60	360	44%	9,600
57	Retail Furniture	28	360	52%	5,242
59	Retail Misc.	68	350	52%	12,376
60	Finance Deposit	45	350	45%	7,159
61	Finance Nondeposit	12	350	52%	2,184
62	Finance Security	13	350	57%	2,600
63	Insurance Carriers	18	350	40%	2,520
64	Insurance Agents	13	350	52%	2,366
65	Real Estate	504	350	40%	70,560
67	Finance Holding	25	350	60%	5,250
70	Hotels	76	210	40%	6,384
72	Personal Services	18	350	50%	3,150
73	Business Services	457	220	34%	33,818
78	Motion Pictures	24	350	20%	1,680
79	Amusement	51	350	52%	9,282
80	Health Services	224	360	52%	41,933
81	Legal Services	2	360	52%	374
82	Education	436	320	71%	99,177
83	Social Services	62	350	71%	15,500
84	Museums	3	350	52%	546
86	Business Associations	65	350	45%	10,341
87	Engineering Services	115	230	70%	18,435
88	Private Households	1	350	52%	182
89	Misc. Services	28	350	29%	2,800
91	Admin. Executive	105	190	50%	9,975
92	Admin. Justice	39	190	55%	4,042
93	Admin. Finance	6	190	52%	593
94	Admin. Human Resources	6	190	50%	570
95	Admin. Environmental	65	190	31%	3,859
96	Admin. Economics	22	190	52%	2,174
97	Admin. Security	3	190	52%	296
TOTALS					580,603

III. Results Summary

The tables below summarize the overall results of the survey. Table 9 describes how the records from the original database were sorted and then used as the basis for the survey.

Table 9 – Database Resolution Summary

	No. Records
ORIGINAL DATABASE	5,813
REMOVED <150 SUMMER kW	426
REMOVED < 500 SUMMER kW	1,522
REMOVED NON-CHILLER BLDG TYPES	810
REMOVED NON-CHILLER INDUSTRIES	190
RECORDS USED	2,865

From those records used as described in Table 9, Table 10 resolves the contacts made and not made during the survey. In this table "bad phone number" represents real customers and "no longer in business" represent customers which may yet have a PSE&G location, but the business activity has moved or been suspended. Of the targeted accounts with high likelihood of having a chiller, 1,753 accounts or 69 percent were contacted and a survey was completed. Of these same targets, 805 accounts or 31 percent resulted in incomplete surveys.

Table 10 – Contact Resolution Summary

	No. Records
RECORDS USED	2,865
SURVEY TARGETS COMPLETE OR PARTIAL COMPLETE	1,753
COMPLETE SURVEY	386
YES CHILLER	212
NO CHILLER	1,155
SURVEY TARGETS NOT COMPLETE	805
NOT CONTACTED	156
REFUSED SURVEY	39
BAD PHONE NUMBER	147
NO RESPONSE	463
NOT SURVEY TARGETS NOT COMPLETE	307
LOW CHILLER PROBABILITY	198
ALTERNATE POWER	9
NOT IN BUSINESS	100

Three to six calls were made to contact the target person, and if after that number of calls were made and contact was still not made, they received the NO RESPONSE code. Sometimes those individuals were in the field and difficult to contact. Sometimes it was impossible to get past a receptionist or other administrator, even after a clear explanation of the reason for the call.

We reached 69 percent of the "real" targeted customers and received at least a partial response. About a third of those customers had chillers and about 65 percent of the responding customers with chillers provided a complete response.

Table 11 summarizes statistics for the accounts with a "COMPLETE" resolution and provides a summary of the total chiller tons surveyed. Table 12 summarized chiller age and type from completed surveys.

Table 11 – Completed Survey Summary Statistics

Completed Surveys	386
Number of Chillers	915
Largest No. Chillers per completed account	15
Average No. Chillers	2.4
Average Tons	~250
Tons from Completed Surveys	230,767
Tons Estimated from Yes Chiller Surveys	172,187
Total Tons, Completed and Estimated	402,954
Total Tons in PSE&G Service Territory	580,600
Estimated Percent Chiller Tons Surveyed	69%

Table 12 –Completed Survey Statistics – Age & Type

Percent Chiller Age Unknown	14%
Average Chiller Age	11.3 years
Percent Chiller Type Unknown	18%
Percent Centrifugal	39%
Percent Reciprocating	30%
Percent Screw	13%

A simple survey response vs. non-response analysis was conducted. For each principal building activity type the number of accounts responding were compared to the total number of accounts. Respondent and overall averages of summer demand were also compared. Table 13 describes these results.

The percent of accounts contacted varies somewhat by PBA, but no building type was significantly over or under sampled. It appears that respondents in general are somewhat "larger" accounts as measured by summer peak demand. This ratio is higher that 1.0 because the survey focused on accounts that would be more likely to have chillers, which were expected to have higher summer demand.

Table 13 – Response vs. Non-Response Analysis

Principal Building Activity	Accounts Contacted	Demand Ratio
Education	38%	153%
Healthcare (inpatient)	46%	171%
Industry	55%	110%
Lodging	51%	125%
Office/Professional	41%	134%
Public Assembly	43%	142%
Public Order & Safety	42%	98%
Retail (all)	33%	178%

IV. Market Segmentation

Market segmentation is a method for treating differently those customer groups deemed to benefit from different approaches. The most likely benefit from market segmentation will be in the development of different approaches for future program marketing activity. Building and chiller size are possible segments as larger systems require longer lead times and those organizations with larger chillers may have longer planning and budget cycles. Chiller age and thus remaining chiller life may be an important differential, as older units will have a higher probability for replacement. Information on plans for replacement or renovations could also drive specific program marketing approaches.

Market segmentation can be used as a means to enable different approaches for marketing campaigns and programs for different populations. A few examples of segmentation analysis from the database are show below.

Table 14 – Market Segmentation Examples

Total Number of Chillers*	915
Total Tonnage*	230,767
Chillers < 100 Tons	346
Total Tonnage	14,475
Chillers ≥ 100 Tons	569
Total Tonnage	216,292
Chillers 20+ years old	132
Chillers 16 -19 years old	56
Chillers 11-15 years old	165
Chillers 6 -10 years old	195
Chillers 0 - 5 years old	241
Commercial Accounts Complete	238
Industrial Accounts Complete	148
Commercial Chiller Tons	136,615
Commercial Chiller Units	450
Industrial Chiller Tons	94,152
Industrial Chiller Units	465

* These numbers include only chillers identified. Some received a "DK" in total tonnage or in chiller age, therefore the values do not total.

Table 15 – Approximate Breakdown of Commercial Chillers by SIC

2-Digit SIC	SIC Description	Chiller Age	Number Chillers	Total Tons
53,56	Retail	12.4	30	10,680
60,62,64,65,67	Finance, Real Estate	14.8	67	23,610
70	Hotels	15.0	13	2,700
73	Business Services	13.9	77	17,048
80	Hospitals	13.1	116	42,067
82	Education Services	9.9	76	24,465
87	Engineering Services	11.8	38	8,799
Various 72-89	Misc. Business and Services	15.8	27	9,397
91-96	Administrative	11.1	32	6,172

Table 16 – Approximate Breakdown of Industrial Chillers by SIC

2-Digit SIC	SIC Description	Chiller Age	Number Chillers	Total Tons	Percent Process
20	Food	9.7	43	15,098	71%
27	Printing	12.0	32	5,372	89%
28	Chemicals (including Pharmaceuticals)	8.6	112	50,459	42%
30	Rubber	7.2	166	5,399	100%
33	Primary Metals	13.0	31	2,103	86%
34	Fabricated Metals	9.6	16	1,969	63%
35	Industrial Machinery	8.5	10	365	100%
38	Instruments	6.3	45	8,068	33%
49	Utilities	3.6	12	4,267	33%
various	Other Industry	15.2	25	6,081	

Responses to Survey Questions

The overwhelming majority of customers responded positively to the question "When you decide to replace your chiller, would assistance in optimizing the overall performance of your chilled water system be of value to you?" with 81 percent answering yes and only 4 percent answering no.

Table 17 – Utility Assistance Value Response

Assistance Valued?	Responses	Percent
Yes	312	81%
No	16	4%
Don't Know	58	15%

The decision process was investigated by asking respondents, "Do you have a decision process that you go through for replacing or upgrading equipment?" Based on verbatim comments by respondents, the decision process was coded into 14 general categories. Their responses are summarized in the table below, in order of greatest occurrence. It is most interesting to note that most of those responsible for maintaining and operating the chiller plant do not know the decision process for capital improvements.

Table 18 – Decision Process Response

Decision Process Description	Responses	Percent
Don't know	80	21%
Consultant recommendation	65	17%
Formal analysis	54	14%
Management decision	53	14%
Board decision	44	11%
Corporate decision	18	5%
Recommend to management	15	4%
None	14	4%
Owner/partner decision	11	3%
Contractor recommendation	8	2%
Economic analysis	8	2%
Decision process varies	6	2%
Submit under budget process	5	1%
In-house decision	5	1%

The timeline for decision making was investigated by asking respondents, "What is your budget cycle? (In other words, how many years before you need to replace or convert a chiller do you need to get that item into the budget?)" Again, most respondents were unaware of their internal budget cycle.

Table 19 – Budget Cycle Response

Budget Cycle Description	Responses	Percent
Don't know	166	43%
Less than 1 year	21	5%
1.0 or 1.5 years	158	41%
2 years	20	5%
3 years or more	21	5%

Most respondents did not know the type of refrigerant used in their chillers. There is still a significant 16 percent of chillers that still use the ozone depleting refrigerants R-11 and R-12.

Table 20 – Refrigerant Type

Refrigerant Type		No. Chillers	Percent
Don't know		331	36%
R-11	(ODP 1.0)	108	12%
R-12	(ODP 1.0)	41	4%
R-123	(ODP 0.02)	52	6%
R-134a	(ODP 0.0)	52	6%
R-22	(ODP 0.06)	308	34%
Other refrigerants		23	3%

ODP is Ozone Depletion Potential

V. Database Description

Database Content
The chiller database contains a total of 2,282 records. These are categorized as follows:

Table 21 – Database Content

Data Category	No. Records	No. Accts
Total Records	2,282	1,753
COMPLETE	915	386
NO CHILLER	1,155	1,155
YES CHILLER	212	212

For convenience and ease of manipulation of the data, each of the data categories noted above is contained on a separate worksheet as part of one MS Excel workbook. An additional worksheet contains the data dictionary of Table 22.

As there are individual records for each chiller in completed surveys, there are fewer accounts represented for this category. This also implies an average of about 2.4 chillers per customer.

The Complete database contains a description of each chiller as gathered during the survey. The resolution in this database is "COMPLETE." Each of the chiller attributes is of importance to a variety of potential future programs and marketing efforts. It contains contact information and backup contacts, information on decision making, and technical details of the chiller and chiller systems. Note that for situations where there are multiple chillers in a facility there are multiple records – one for each individual chiller.

The Yes Chiller database came about because in some cases it was only possible to ascertain that the building used chillers for air conditioning or process, but no specific data could be collected. For these the resolution is coded "YES CHILLER." For these accounts no other information or very little information is available. An estimated total chiller capacity was imputed and shown as "estimated."

The remaining database contains those accounts that do not have chillers. This information was recorded when it was determined that no chiller was present at the facility. For these, the resolution is coded "NO CHILLER."

Occasionally there are several account numbers for a single service location and customer. Under these circumstances, if there the customer has a chiller, only a single account numbers will be shown.

A table of database fields is provided on the next page.

Database Usage
Program needs and parameters will dictate how the database is to be used. By making some assumptions about program design, we can suggest how the database might be used. Below we provide several examples of database usage.

Example 1
With a simple, non-targeted approach to marketing a chiller optimization program nearly all customers might be contacted. By using the database of "NO CHILLER" accounts, those customers can be purposefully excluded from receiving this blanket marketing message. Also, if a unitary air conditioning program is marketed, those in this "NO CHILLER" database are reasonable first candidates to be approached.

Example 2
Retirement of CFC-based refrigerants may be a concern for some customers. The continued use of CFC-based refrigerants may create problems for those customers that have a plan for refrigerant upgrades and it certainly does for those that have yet to prepare a plan. The survey results show that at least 16 percent of chillers use these refrigerants. Most of these chillers are also older and less efficient. By sorting the "Complete" surveys according to refrigerant type, those chillers that still use R-11 and R-12 can be selected. These customers can then be contacted with specific program information about efficiency improvements to consider when upgrading refrigerants or replacing chillers.

Example 3
A chiller optimization program marketing approach could focus on a particular industry. The primary metals industry is not particularly significant in PSE&G service territory or in their use of chillers, but their equipment is substantially older than the average. It may then benefit most from efficiency improvements. By sorting by industry and refrigerant and age, PSE&G could confirm whether there are a significant number of chillers with obsolete refrigerants, and older chillers. This would help confirm if there is a significant potential target market. By teaming with a consultant that has demonstrated and specific skills in process cooling in this industry, a focused approach to these customers could have good credibility. Marketing materials specific to this industry could be prepared that address the concerns of this industry and also describe efficiency improvements for chiller systems common in the industry.

Example 4
The marketing of other programs could benefit from the information collected in this project. The Complete database has current and accurate contact information and phone numbers. This contact information leads directly to a person with familiarity with their facilities mechanical and other energy using equipment. The database often also has the name of a primary and secondary decision-maker that could be used for program marketing that would benefit from a approach to a higher level in the organization.

Table 22 – Data Dictionary

FIELD NAME	DESCRIPTION
Acct. No.	PSE&G Account Number
Account Name	May be updated to reflect changed owner or company name.
Service Address	
Service City	
Service Zip	
Service State	
Service Area Code	
Service Telephone	
1999 Summer kW	
SIC	2-digit SIC as reassigned
Survey Date	
Surveyor Initials	
Survey Target Name	
Survey Target Title	
Survey Target Phone	Provided if different from Service Area Code/Service Telephone
Resolution	COMPLETE, YES CHILLER (there are chiller(s), but survey was not completed), or NO CHILLER
Number of Chillers	
Total Chiller Tons	Total tonnage of all chillers combined
Chiller ID	Naming convention used to identify chillers, if any
Type	Centrifugal, Reciprocating, Screw (C, R, S, DK)
Chiller Manufacturer	
Op Status	Operating Status—Primary, Backup, Lead Lag (P, B, L, DK)
Chiller Tons	
Size Opinion	Opinion of Target on chiller size as Oversized, Undersized, Rightsized (O, U, R, DK)
Chiller Age	Age in Years (Age, DK)
Last Overhaul	Year last overhaul (Year, N, DK) N=Never
Replacements	Year replacement or upgrade planned (Number of years, Y, N, DK) Y= Replacement/upgrade planned, year unknown
Conversions	Year conversion planned (Number of years, Y, N, DK) Y= Conversion planned, year unknown
Refrigerant Type	(Type, DK)
Load Type	Office space, Classroom, Process, Retail, Other (O, C, P, R, Other, DK)
Area Served	Square footage, if applicable (Square footage, NA, DK)
Key Decision Name	Name of person who is key in decision making
Key Decision Title	Title of person who is key in decision making
Budget Cycle	Years
Decision Process	What the decision process "looks like"
Assistance Value	Would they value assistance to optimize performance of chiller system? (Y, N, DK)
Prime Contact Name	Name of person to contact
Prime Contact Title	Title of person to contact
Prime Contact Phone	Phone of person to contact, if different than Service AC/Telephone
Prime Contact Address	Address of person to contact, if different than Service Address
Alt Contact Name	Alternate name of person to contact
Alt Contact Title	Alternate title of person to contact
Alt Contact Phone	Alternate phone of person to contact, if different than Service AC/Telephone
Alt Contact Address	Alternate address of person to contact, if different than Service Address

NA = Not Applicable, DK = Don't Know

APPENDIX

Chiller Survey Instrument

Chiller Survey ver 10-27

General Customer Information

ID: _____
Date of Interview: _____
Target Name:_____
Target Title [if determined]:_____
Telephone: _____
Account Name: _____
Address: _____
City: _____

Introduction Script:

Hello, my name is _____. I'm calling on behalf of Public Service Electric & Gas of New Jersey and I am trying to reach ___(Target)___. Is she/he available?

[If no ask: "When would be a good time for me to call back?" *schedule if possible.]*

[Confirm Target when reached.]
Are you the right person to talk with about the air conditioning system in the __[Account Name]__. building located at [Address]___ in ___[City]___?
[If no, collect information on other building, if chillers.]

[Confirm presence of chillers.]
Does the in the __[Account Name]__ building use chillers for air conditioning? *[Confirm as necessary their assertion,* "provides chilled water, not rooftop system, etc."*]*

The building does not have chillers ____.
[If yes, complete the survey, confirm Target Title.]

[Multiple building management.]
Do you know about air conditioning chillers in any other building that may be served by PSE&G?
[If yes and possible, complete the survey for additional buildings. If other persons responsible, collect additional Target information. Collect address and city. If possible, determine ID before completing the interview by searching the database.]

Scheduling Notes:

_____

Survey
Public Service Electric & Gas (of New Jersey) is planning to offer incentives to improve the efficiency of customer cooling systems, including electric chillers. We are calling to learn a few things about customer chiller systems and their needs for assistance regarding their chillers. Depending on how many chillers you have, there are about twenty questions that usually take less than 10 minutes. Your answers are confidential and will not be used outside the utility. Can we start now? *[Continue if yes, reschedule if no or wrong Target.]*

Overall System Questions
1. What is the total number of chillers in your facility?_____

2. What is the total tonnage of your chiller plant? _____

3. **Chiller Table**
(Note to interviewer: The Chiller ID is the name or number that the building staff, owner, or engineer has assigned to each chiller for example, C-1, C-2, C-3 or Library, Science Bldg., etc.). To begin the table you may want to explain that you would like to gather information on each chiller that they have by using the number or name that they typically use to identify their chillers.

Customer Chiller ID →			
Type (centrifugal, screw, reciprocating C,S,R)			
Brand (Manufacturer, if known)			
Is this chiller considered primary, backup, lead/lag? (P,B,L)			
Size in tons cooling capacity			
In your opinion, is the chiller undersized, oversized, or the right size? (U,O,R)			
Age, years			
When was the last major overhaul (year)			
Are you planning any replacements If yes, ask when? (time frame, range of years)			
Are you planning any conversions? If yes, ask when? (time frame, range of years)			
Refrigerant type			
Load type (office space, classroom, process, etc. O,C,P)			
Approx. square footage served by chiller (optional)			

Management Questions:

4. Who has the key responsibility for deciding to replace or upgrade the chiller system or piece of equipment?
Name: _____
Title: _____

5. What is your budget cycle? (In other words, how many years before you need to replace or convert a chiller do you need to get that item into the budget?)
Years: _____
Don't know: ___

6. Do you have a decision process that you go through for replacing or upgrading equipment?
[Provide examples if necessary, board approval, engineering study, VP facilities, etc.]

Program Questions

7. When you decide to replace your chiller, would assistance in optimizing the overall performance of your chilled water system be of value to you?
Yes: _____
No: _____
Don't know: ___

8. Who should we contact in the future regarding any utility program offerings that relate to chiller systems?
Name *(confirm spelling)*: _____
Title: _____
Phone: _____
Address (confirm): _____

9. If (above person) isn't available is there anyone else we should talk to?

Name *(confirm spelling)*: _____
Title: _____
Phone: _____
Address (confirm): _____

Thank you for your time.