1995 Nonresidential New Construction Program

First-Year Load Impact Evaluation

SDG&E Marketing ID No. MPAP-95-P52-971-703
Study ID No. 971

Submitted to:

San Diego Gas & Electric Company
8306 Century Park Court
San Diego, California 92123

Submitted by:

Regional Economic Research, Inc.
12520 High Bluff Drive, Suite 220
San Diego, California 92130
(619) 481-0081

Revised March 5, 1997

Table of Contents

1

Introduction

1.1 Overview

This report presents the findings of an evaluation of the impacts of San Diego Gas & Electric Company's 1995 Nonresidential New Construction Program. The evaluation was conducted by a team consisting of three firms: Regional Economic Research, Inc. (RER), VIEWtech, Inc. (VIEWtech), and CIC Research, Inc. (CIC). The study was designed to comply closely with the provisions of the California Public Utilities *Commission's Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs* (the CPUC M&E Protocols).

San Diego Gas & Electric Company (SDG&E) initially filed for first year earnings based on estimated gross program savings of roughly 39.7 GWh. The CPUC Division of Ratepayer Advocates (DRA) took issue with SDG&E's means of estimating savings, and recommended that this level of savings should be reduced for the purposes of the *ex ante* payment. SDG&E ultimately agreed with DRA (now ORA) that estimated *ex ante* savings would be reduced by 20.8% as a means of accommodating the perceived overestimation of savings. Thus, the gross savings estimate was reduced to 31.4 GWh for this purpose. The results of the study suggest that the program generated net savings fairly close to the estimate actually used of this first year earnings claim.

The remainder of this section provides a brief description of the 1995 Nonresidential New Construction Program, identifies evaluation objectives, presents an overview of the evaluation methodology, and previews the rest of the report.

1.2 Description of Program

Overview

Since 1995, the Nonresidential New Construction Program has been marketed as the Savings Through Design Program. The program offers incentives to builders to promote the enhancement of energy efficiency in new construction. In 1995, the program offered both prescriptive and performance options. Under the performance option, incentives were provided to builders who exceeded Title 24 standards by at least 10% in at least one end use, while satisfying Title 24 for other end uses. With the prescriptive option, incentives were paid for the adoption of specific measures, but the requirement of 10% improvement over Title 24 was nonetheless maintained. These options are discussed below.

Savings Through Design Performance Option

The 1995 performance option offered cash incentives to builders willing to revise their building plans to exceed Title 24 standards and achieve energy savings of 10% or greater in one or more of the following categories: cooling, heating, lighting, fans/motors, pumps, and hot water. Only one project was actually funded under this option in 1995. It involved a project built in 1995, although the Title 24 design review had been completed for the project in 1993. Because it was used mostly when buildings were energy deficient, the performance option was phased out in 1995.

Savings Through Design Prescriptive Option

The Savings Through Design Program's Prescriptive Option is designed to encourage the incorporation of energy-efficient technologies into the design of commercial buildings by providing assistance with the review of building plans, offering cash incentives for standard and custom measures, and educating target audiences through a variety of communications tactics. The Savings Through Design Program's Prescriptive Option encourages the installation of new construction projects which exceed building energy-efficiency standards, including California's Title 24 Standards.

SDG&E continued to improve its communication with the architectural, engineering, and development communities through Title 24 seminars, the "Progress Through Design" newsletter, case studies, testimonials, and personal contacts. The new construction field office continued to serve the design and construction community. SDG&E also sponsored two seminars for the architectural and engineering communities. Program presentations were also made to such organizations as the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), the American Institute of Architects (AIA), the Illumination Engineering Society (IES), and the Building Owners' Management Association (BOMA).

The prescriptive lighting efficiency option and the options for mechanical, glazing, and custom measures (reported separately in previous years) were combined in 1995. A total of 332 contracts were completed under the prescriptive option of the Savings Through Design Program in 1995.

1.3 Evaluation Objectives

The fundamental purpose of the project was to estimate the impacts of the 1995 Savings Through Design Program. The evaluation had three specific objectives, including:

- Assembly of a comprehensive database relating to the behavior of participants and nonparticipants.
- Development of first year gross realized energy and demand impacts of the measures installed under the program.
- Estimation of first year net energy and demand impacts. These impacts were designed primarily to take into account free ridership and participant free drivership, although an attempt was also made to assess nonparticipant free drivership.

1.4 Overview of Methodology

The overall methodology will be designed to comply with both the principles of good evaluation and the dictates of the CPUC M&E Protocols. The methodology consisted of four primary elements.

- ***On-Site Survey.*** An on-site survey was conducted in order to collect information on participants and nonparticipants. The survey was used to collect detailed information on equipment stocks, building characteristics, operating schedules, occupancy rates, Title 24 compliance, and stocks of demand-side management (DSM) measures. The survey design involved an attempted census of all participating sites and a roughly matching sample of nonparticipant sites. The total completed sample included 253 participants and 159 nonparticipants.
- ***Decision-Maker Survey.*** A decision-maker survey was conducted to support the analysis of the net influence of the program on DSM behavior. The survey was completed for a large subsample of participant and nonparticipant sites.
- ***Estimation of Gross Impacts.*** Gross impacts can be interpreted as the effects of DSM measures on participants' energy usage, without regard to the attribution of these impacts to participation in the program. The gross impacts of the program were estimated using a hybrid statistical/engineering approach. This approach entails the use of DOE-2 building simulations to develop preliminary estimates of measure impacts, and the use of a load impact regression model to statistically reconcile these simulation estimates with billing information.
- ***Estimation of Net Impacts.*** Net program impacts are those that are attributable to the program. They are typically derived through the adjustment of gross savings to account for free ridership, free drivership, and (in some studies) market transformation. The ratio of net impacts to gross impacts is sometimes characterized as a net-to-gross ratio. Net-to-gross ratios were estimated for each

end use through three approaches: (1) the use of self-reported estimates gleaned from the decision-maker survey; (2) the use of the difference of differences approach; and (3) the development and application of an efficiency model designed to discern the net influence of the program on adoptions of energy-efficiency measures. The net-to-gross ratios ultimately chosen for the determination of net savings were those based on the simple difference of differences approach. It should be noted that it yields *lower* net savings than the model-based approach.

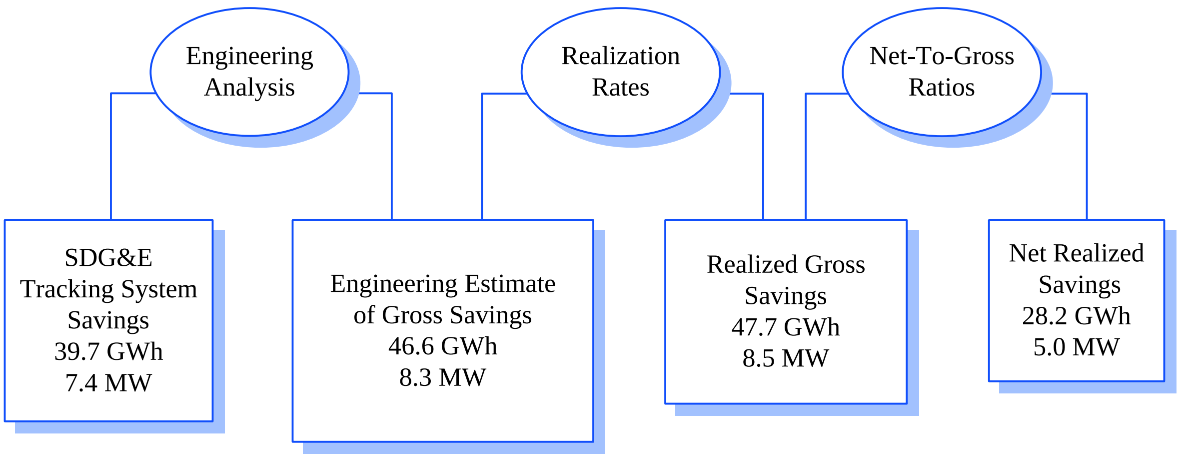
1.5 Summary of Results

The results of the study are summarized in Table 1-1 and illustrated in Figure 1-1. As indicated, SDG&E's tracking system recorded an estimated 39.7 GWh and 7.4 MW of gross program savings. These savings were the basis for SDG&E's initial first year earnings claim, as explained above, but were not ultimately used for the purposes of earnings payment. The engineering estimates developed as part of this study amounted to 46.6 GWh and 8.3 MW. It should be recognized, however, that these estimates covered both incentivized and non-incentivized measures, and are not directly comparable to SDG&E's program estimates. The realization rate analysis conducted as part of the study reconciled the engineering calculations against actual billing records. As depicted in Figure 1-1, this analysis had little impact on the estimates, suggesting that the overall realization rate on gross savings was very close to 1.0. The net-to-gross analysis indicated the presence of a substantial free-rider effect. After being adjusted for this effect, net savings from the program amounted to 28.2 GWh and just under 5.0 MW.

Table 1-1: Summary of Program Savings Estimates

Impact Measure	Engineering Estimate	Realization Rate	Realized Gross Savings	Net-to-Gross Ratio	Net Savings
Total Program Savings					
Energy (GWh)	46.570	1.024	47.686	0.591	28.200
Demand (MW)	8.315	1.019	8.469	0.588	4.977
Savings per Square Foot					
Energy (kWh)	3.761	1.024	3.851	0.591	2.277
Demand (W)	0.672	1.019	0.684	0.588	0.402
Savings per Building					
Energy (kWh)	163,405	1.024	167,321	0.591	98,948
Demand (kW)	29.177	1.019	29.716	0.588	17.459

Figure 1-1: Overview of Estimate Program Savings



1.6 Preview of Remainder of Report

The remainder of this report is organized as follows:

- Section 2 discusses the development of the sample design underlying the collection of data on participants and nonparticipants,
- Section 3 describes the design and administration of the on-site survey,
- Section 4 discusses the use of building simulations and other engineering algorithms to develop engineering estimates of savings for program and non-program measures installed by participants and nonparticipants,
- Section 5 explains the use of a realization rate approach to estimate the gross realized savings associated with program and non-program measures,
- Section 6 discusses the estimation of net program impacts, and
- A series of appendices contain technical details on several aspects of the analysis.

2

Sample Design and Selection

2.1 Overview of Sample Design

The sampling strategy used for this evaluation was straightforward. It entailed the following elements:

- First, SDG&E chose to sponsor an attempted census of all 1995 program participants. The CPUC M&E Protocols require such a census when a program has fewer than 350 participants in the program year in question. As will be explained below, there were 285 distinct participating sites in the 1995 program.
- Second, a roughly matching sample of nonparticipants was chosen to act as a control group in the analysis of gross and net program impacts.

Additionally, an attempt to conduct a decision-maker survey was to be made for each of the sites agreeing to participate in the on-site survey. The implementation of this design was complicated somewhat by practical difficulties in defining participant and nonparticipant sites and matching nonparticipant samples with participant samples. The means of resolving these difficulties are discussed below.

2.2 On-Site Survey Design

Participant Sample Design

Definition of Participant Sites. Information on participants was provided by SDG&E at the beginning of the project. The following types of identifying data were made available:

- ***Program Contracts.*** A listing of program contracts was provided by SDG&E. Individual contracts were also made available in hard-copy form with supporting documentation.
- ***Premise Numbers.*** Each contract specified one or more premise numbers. In some cases, a single contract covered a single customer premise; in other cases, a contract may have encompassed several distinct premises; in yet other instances, multiple contracts applied to a single premise.

- ***Account Information.*** SDG&E also provided a preliminary list of accounts and meter numbers associated with each premise. Billing records for these accounts were also merged into the participant database.

Based on this information, RER proceeded to define a set of unique sites for the purposes of the analysis. These sites were defined as the units at which the building simulation and statistical analyses were to be applied. These sites varied considerably in their general description, being various portions of buildings, entire buildings, or sets of buildings, depending on the specific circumstances. The following general rules of thumb were used to develop their definitions:

- If a single building was treated through the program (which would typically be the case if the participating site was truly new construction), and if the building was separately metered, then the building was defined as the relevant site. The entire building was surveyed and all of the electricity accounts associated with the building were used in the billing analysis.
- If a single building was treated, but was on a meter covering more than one building, the full multiple-building area covered by the relevant meter was defined as the relevant site as long as it was not more than five times as large as the treated building. If the metered area was more than five times as large as the treated building (which happened in only a few cases), only the treated building was surveyed. In this latter event, the site was covered by the building simulation analysis, but was left out of the billing analysis because of the lack of appropriate billing data.
- If only a portion of the building was covered by the program (which could be the case for an addition, a major remodel, or tenant improvements), that portion of the building was used as the relevant site if it was separately metered or submetered. This was generally the case, insofar as tenant improvements and remodels tended to cover separately metered suites within buildings. If the relevant meter covered more than the space covered by the program, the larger metered area was defined as the appropriate site as long as it was not too much larger than the covered area. In the case of single-tenant buildings, the metered area was used if it was less than five times the size of the covered area. In the case of multi-tenant buildings, the metered area was used as long as it was less than twice the size of the covered area. Note, of course, that multi-tenant buildings are almost always metered separately for individual tenants, so this criterion was almost always met for such buildings.
- If multiple buildings were covered by the program at a single premise, each building was considered a distinct site unless it was served by a central HVAC facility that also served other buildings at the premise. When central multi-building HVAC systems were encountered, all buildings served by the HVAC facility were included in the site unless their total square footage exceeded five times the area of the covered building. In this latter case, the treated building was

defined as the relevant site and the building was surveyed and covered by the building simulations but excluded from the billing analysis.

Participant Sample Frame. After applying these rules of thumb, a list of 285 distinct participant sites was defined. The distribution of these sites across building categories is presented in Table 2-1. Some sites were intentionally deleted from this list for the purposes of the survey. Military sites were excluded from the frame because of the difficulty of obtaining the appropriate clearances to survey these sites. A few other sites were disqualified because of the known unwillingness of site owners to permit additional on-site inspections. This left an initial sample of 279 distinct sites that were candidates for the census.

Table 2-1: Development of Participant Sample (number of sites)

Building Category	Participant Population	% Dist	Participant Frame	% Dist	Completed Sample	% Dist
Assembly Plant	32	11.2	31	11.1	20	7.9
Churches/Meeting	7	2.4	7	2.5	7	2.8
College/University	17	6.0	17	6.1	17	6.7
Convenience Store	3	1.1	3	1.1	3	1.2
Grocery	18	6.3	18	6.5	18	7.1
Hospital	5	1.8	5	1.8	5	2.0
Lodging	4	1.4	4	1.4	3	1.2
Offices	59	20.7	58	20.8	51	20.1
Restaurant	26	9.1	26	9.3	26	10.3
Retail	37	13.0	37	13.3	37	14.6
School	38	13.3	38	13.6	38	15.0
Warehouse	6	2.1	6	2.1	4	1.6
Misc./Other Comm.	29	10.2	26	9.3	21	8.3
Other Process	4	1.4	3	1.1	3	1.2
All Bldg Categories	**285**	**100.0**	**279**	**100.0**	**253**	**100.0**

Survey Response. Participants were recruited for both the on-site survey and the decision-maker survey by CIC Research, Inc. As shown, the recruiting process was extremely successful. Moreover, the participant response rate was uniformly high across building categories. Of the 279 participant sites in the frame, 253 were ultimately subjected to an on-site survey. Contacts at the remaining 26 sites declined the opportunity to allow surveyors to enter their sites. The response rate for participants was just under 91%.

Nonparticipant Sample Design

Nonparticipant Frame. A population frame of nonparticipant sites was developed using building permit records for 1994 and 1995 for construction completed in 1995. These records contained information on site name and address, an estimate of square footage, and a four-digit SIC number. SDG&E reviewed the frame data and allocated individual permits to specific premises using addresses. SDG&E then used these premise identifiers to merge billing records into the nonparticipant frame database. For lack of more information on the circumstances surrounding the permitted construction activities, the resultant premises were defined as sites for the nonparticipant sample design—485 sites were so identified.

Nonparticipant Sample Design. The next step was to develop a nonparticipant sample design and a listing of sampled sites. The general principle underlying this element of the sample design was that the initial nonparticipant sample should match the initial participant sample (which, given the participant census, was also the entire participant population) reasonably closely. Early in this phase of the analysis, it was decided that this matching should be on the basis of building category. While an attempt to match consumption could also have been made, this possibility was dismissed because of the systematic difference expected to be found between participant and nonparticipant populations. Moreover, matching square footage as well as building type would have been difficult to implement, given the small nonparticipant population.

Table 2-2 summarizes the distributions of participants and nonparticipants across building categories. As shown, these distributions are fairly different. This is not surprising, given that some types of building categories (e.g., hospitals and universities) are generally more likely to participate in energy-efficiency programs than other categories. Nonetheless, it forces one to make some compromises in the course of attempting to develop matching samples of participants and nonparticipants. Table 2-2 also indicates the total number of completions for the nonparticipant on-site survey. The overall nonparticipant response rate for the on-site was just over 63%, and the response rates for individual building categories ranged from zero to 100%. The overall completion rate was considerably lower than for participants, but the reasons for this are considered below.

Table 2-2: Development of Nonparticipant Sample (number of sites)

Building Category	Participant Frame	% Dist	Non-participant Population	Nonpart. Target Sample	Completed Nonpart. Sample	% Dist
Assembly Plant	31	11.1	36	30	7	4.4
Churches/Meeting	7	2.5	17	9	12	7.6
College/University	17	6.1	5	5	1	0.6
Convenience Store	3	1.1	12	4	8	5.1
Grocery	18	6.5	3	3	3	1.9
Hospital	5	1.8	3	3	1	0.6
Lodging	4	1.4	9	9	5	3.2
Offices	58	20.8	130	65	24	15.2
Restaurant	26	9.3	53	33	32	20.3
Retail	37	13.3	57	46	20	12.6
School	38	13.6	8	7	2	1.3
Warehouse	6	2.1	26	8	10	6.3
Misc./Other Comm.	26	9.3	96	28	23	14.6
Other Process	3	1.1	13	0	1	0.6
Unclassified	0	0.0	59	0	9	5.7
All Categories	**279**	**100.0**	**527**	**250**	**158**	**100.0**

Nonparticipant Survey Response. The response rate for nonparticipants was partly due to the large number of sites that were disqualified for one reason or another from the survey. Table 2-3 provides a summary of the disposition of these sites. As shown, preliminary screening revealed that many sites were duplicates (more than one building permit had been pulled for the site). Another 203 were not qualified, in the sense that they had not done a major remodel, tenant improvement, or new construction at the site. This left only 209 qualified distinct sites, 158 of which agreed to the survey. The response rate for qualified sites was 76%.

Table 2-3: Nonparticipant On-Site Survey Disposition Summary

Disposition	Number of Sites
Nonparticipant Sample Frame	**527**
Duplicate Site	115
Not Qualified for Survey	203
Total Qualified Sites	**209**
Refused to Participate in Survey	51
Total On-Site Survey Completions	**158**

2.3 Decision-Maker Survey

Participants and nonparticipants were recruited for the decision-maker survey only if they agreed to the on-site survey. In some cases, a single decision-maker represented more than one distinct site. As shown in Table 2-4, 232 decision-maker surveys were completed, representing 328 sites. In terms of sites, decision-maker surveys were completed for over 84% of the participants and 73% of the nonparticipants receiving an on-site survey.

Table 2-4: Summary of Decision-Maker Survey Coverage

	Decision-Maker Survey Completions		On-Site Survey Completions	Decision-Maker Survey Completion Rate
Category	**(Individuals)**	**(Sites)**	**(Sites)**	**(Sites)**
Participants	122	213	253	.84
Nonparticipants	110	115	158	.73
All Sites	232	328	411	.80

3

Data Collection

3.1 Overview

Three types of data were collected to support the analysis: on-site data on a sample of participants and nonparticipants; decision-maker data for the key decision makers associated with these sites; and auxiliary data like billing histories, weather data, and information on participation in other SDG&E programs. The next three subsections discuss the collection of these elements of the overall project database.

3.2 On-Site Survey

Introduction

On-site visits were made in order to verify installation of program measures, identify other measures installed at the sites, and collect information on site features and operating schedules to be used in the building simulation and econometric analyses. The quality and comprehensiveness of the on-site survey was considered critical to the success of this evaluation.

Development of On-Site Survey Instrument

The survey instrument used in the on-site survey had to accommodate the rather stringent requirements of DOE-2. The survey instrument used for the on-site survey is included in Appendix A. An earlier version of this instrument had been developed by RER in the course of other nonresidential on-site data collection efforts, many of which were designed to support DOE-2 simulations. However, the form was modified to make it more useful in this specific application.

Recruitment of Customers for the Survey

As a first step in recruitment, a letter from an SDG&E representative was sent to customers in the primary sample. These letters were staged to precede telephone contact by one to two weeks. The second step involved a telephone call to the customer location. This was performed by CIC Research. CIC used a centralized approach for recruiting customers. The centralized approach offered the following advantages:

- ***Careful and Consistent Treatment of Customers.*** The centralized approach was carried out by two or three people. These individuals are trained in recruitment techniques and have previous experience performing this task. The use of a small number of centralized recruiters ensured that customers were contacted in a consistent manner.

- ***Weekly Scheduling Updates.*** With a centralized approach, all the scheduling information was maintained in one place. At the end of each week, all information was compiled and transmitted to the SDG&E project manager. The SDG&E project manager, in turn, disseminated scheduling information for the assigned accounts to the account executives and to other appropriate individuals at SDG&E.

CIC personnel executed the following recruitment procedure:

- Make contact with the customer and verify or identify the appropriate person for discussing participation in the study. Explain the purpose of the project.
- Solicit participation in the on-site survey. Indicate the amount of time needed during the visit from the contact person or from other individuals knowledgeable about the facility and business operations.
- Arrange a mutually acceptable time for data collection. In arranging the visit, care wa taken not to schedule the visit during important activities at the facility.
- Request that selected information be made available for the surveyor to review. This information included copies of bills and blueprints and facility listings, if appropriate.

As the scheduling team established appointments, the master schedule and recruitment database were updated and reviewed by the VIEWtech project manager. The updated schedule and database were also provided to the RER field work manager, the SDG&E project manager, and the surveyors. In cases where it was not possible to schedule the survey, the reasons for refusal were included in the recruitment database. Once an appointment was made, a postcard was sent to the site contact confirming the date for the visit.

Training of On-Site Surveyors

A two-day training workshop was conducted for all engineers assigned to the project prior to the commencement of the field work. The training workshop was conducted using training manuals and materials developed specifically for this project. The instructors were the

VIEWtech field supervisor and the RER field work manager. The training session addressed the following issues:

- Overall project purpose and scope.
- Roles and relationships of project parties (SDG&E, RER, and VIEWtech).
- The details that are to be recorded to describe mechanical systems and equipment for HVAC and non-HVAC end uses.
- The physical characteristics of the site, including construction materials, building geometry, and other characteristics relevant to estimating HVAC loads.
- The appropriate techniques for recording the technical information.
- Key elements in business operations including operating hours, system control settings, and estimated equipment usage levels and usage profiles.
- The appropriate interview techniques for eliciting information about business characteristics and operations.
- An explanation of the codes used on the survey form.
- The definition of the survey site as the entire customer premise at the service address and examples of how to configure forms for specific situations.
- Quality control procedures that must be exercised by the surveyors before the survey is considered "complete."

In addition, the RER field work manager explained how the data elements are used in the analysis. This understanding was critical to ensure that all data fields on the survey form are treated with equal care. Following the two-day workshop, the surveyors as a group went to several sites to review the data collection procedure using live cases. The sites were chosen to cover the full spectrum of equipment.

Preparation of Customer Information Sheets

All surveyors were provided with background information for each sample site prior to the on-site visit. The information was provided in the form of a Site Information Sheet that presented the following:

- Site descriptions, including site names, addresses, and square footage,
- Contact person information,
- Monthly billing data for electric and gas accounts at the site,
- A list of specific measures rebated for the site, and
- Comments relating to the site.

This information was provided to the surveyors for their review prior to the on-site visit. In addition, other information (e.g., site maps) was included for complex sites. Figure 3-1 depicts a sample Site Information Sheet.

Conduct of On-Site Visits

The procedure used in on-site visits was as follows:

- Upon arrival, the surveyor interviewed the site contact about general site operations and characteristics. The interview portion roughly corresponds to the first section of the survey form presented in Appendix A. The interview usually took between 20 and 30 minutes.
- Upon completion of the interview, the surveyor walked through the facility and recorded equipment, building, and operating information. Depending on the wishes of the site contact, the surveyors proceeded by themselves, or the site contact or other representative accompanied the surveyor through the facility.

In addition to the interview and the walk through, data were obtained from other sources, including the following:

- ***Site Documents and Records.*** Structural and architectural drawings can provide data on building dimensions and construction materials. Mechanical, electrical, and plumbing plans can provide data about end-use equipment. Title 24 compliance documents can also offer considerable information about site design.
- ***Energy Usage Information.*** When necessary, energy bills were obtained from site contacts in order to facilitate the process of matching sites and usage.
- ***Measurements.*** The surveyor used measuring devices as necessary to record floor stock, lighting levels, and the presence of electronic ballasts.
- ***Photographs.*** Finally, surveyors took photographs of the exterior of the survey area and the HVAC equipment. This visual information was often useful input for the design of the building the simulations.

Figure 3-1: Site Information Sheet

Not available electronically.

All on-site survey data went through a two-stage quality control procedure. First, the survey data passed through the VIEWtech process, from surveyor to field supervisor, as discussed below. Then, these data were passed on to the RER team for further review. Quality control ran concurrently with the data collection effort, as described below.

All incoming surveys were monitored by VIEWtech and RER staff to ensure the quality of the responses. In the first stage of quality control, VIEWtech executed the following procedure for each site:

- Surveyors were required to perform a variety of "sanity checks" before they leave the survey site. These include the following:
  - Compute overall electric intensity, using billing information and square footage estimates.
  - Compute equipment densities, including square feet per ton of cooling equipment and Watts per square foot of lighting equipment. Compare the sum of the equipment densities with the maximum recorded monthly demand.
  - Estimate annual energy use as the sum of the end-use components and compare it with the utility bill information.

  If the data did not pass these initial checks, the surveyor continued at the site to clear up any obvious discrepancies.
- The completed survey form was delivered to the VIEWtech field work supervisor. The supervisor reviewed the form and the sanity checks performed by the surveyor. Any missing data or apparent inconsistencies were resolved by the supervisor manager and the surveyor.
- During the data collection process, the VIEWtech field work supervisor periodically rode along with field surveyors to ensure ongoing compliance with survey procedures and to ensure survey continuity.

It was occasionally necessary to take follow-up steps to collect data that were missing or that appeared to be inaccurate from the initial data collection effort. The follow-up (by telephone or, when necessary, a second visit to the site) was conducted by the surveyor who did the initial survey work, or by the VIEWtech field work supervisor, depending on the specific circumstances of the case.

Communication. The following steps were taken to ensure that all members of the project team (RER, VIEWtech, CIC and SDG&E) were well informed:

- All field personnel carried pagers to facilitate communication between field staff and project management. Whenever possible, questions were handled at the time of the on-site survey to eliminate the need for repeat visits.

- Weekly project staff briefings were held to communicate pertinent information to field staff, and to obtain feedback and provide clarification on any issues which may have arisen during the on-site visits.
- During the field work, the VIEWtech field work supervisor was in daily contact with RER's project manager to provide a detailed progress update and to discuss any problems that may have arisen. In turn, the VIEWtech field supervisor and RER project manager kept close contact with the SDG&E project manager, to ensure that any questions or concerns are addressed in a timely manner.

Survey Data Entry and Database Preparation

As the incoming surveys were reviewed by the VIEWtech field work supervisor, they were also be precoded for data entry. All data, including comments in the margins and notes sections of the questionnaire, were reviewed. The survey data were entered into a database using SAS. All data, including comments in the margins and notes sections of the questionnaire, were entered into the database. The data entry system included data verification procedures that identify inappropriate or incorrect responses. The raw survey forms, the data entry system, and the resulting SAS databases were all provided to SDG&E.

A code book covering all datasets to be delivered by RER was also be prepared by CIC. The code book contained one section per dataset and listed the variable name, variable description, variable type, variable length, response range, and the corresponding value labels, describing each of the valid responses for each field. Other deliverables associated with the code book included: (a) a copy of the survey form with annotations that provide all field names, and (b) a SAS program to create a SAS-format library including the value labels mentioned above.

Survey Data Validation

After the survey data were entered into the database, they were transferred to RER where they went through two stages of error checking:

- The first stage detects errors and inconsistencies in the data for a given facility. RER performed exhaustive premise level analysis of the data as each survey was received from the field. This activity included data validation checks, like flagging motor sizes or lamp wattages that are not available in the market, identification of space-utilization definitions that were not consistent with the site activity description, and similar checks on literally hundreds of other items that are potential sources of data pollution.
- The second stage was designed to detect internal inconsistencies within the database. Sites were grouped by type, and the data for sites of each type were processed through a set of statistical analysis routines.

Preparation of Inventory Reports

As part of the error-checking and review process, a series of inventory reports was produced. The purpose of these listings was to allow visual inspection of the raw data. These reports provided a comprehensive summary for each case in the database and summarized the types of equipment at each site and the corresponding connected loads. These listings are designed to allow project analysts to “zoom in” on the data for a specific topic or the data for a specific case. An example of an inventory report is contained in Appendix C.

Multiple Accounts Reconciliation

The linkage of billing data with surveyed sites was an absolutely critical step in the overall analysis of program impacts. No amount of elegant simulation and econometric analysis can overcome poorly matched billing data. Special emphasis was placed on the accurate identification of meters at the surveyed sites. Multiple-accounts reconciliation took place at five points during the project.

- First, accounts were aggregated to customer locations in the sample-design phase.
- Second, surveyors verified the account matching during the on-site visit. Changes in account numbers were recorded on the survey form.
- Third, for the sites for which the surveyors had complete billing information, they computed energy intensities while at the site. Intensities that were out of the “reasonable” range were investigated with the customer contact. Potential problem sites, or ones for which intensities could not be computed, were flagged for follow-up by the RER analysis team.
- Fourth, the billing information was reviewed by RER staff. Again, the intensities were reviewed and problems were flagged for follow-up with the SDG&E project manager.
- Finally, when the simulations were performed, the results were compared with the billing data. If the simulation and billing data differed substantially, and there appeared to be no problems with the survey data, these cases were reviewed further.

3.3 Decision-Maker Survey

The decision-maker survey was designed to collect information relating to the factors influencing the installation of DSM measures at the subject sites. Several types of questions were asked in the survey, which was administered by phone. For both participants and nonparticipants, the survey solicited information relating to the following issues:

- Total recent construction activity,
- Reason for constructing the site in question (owner occupancy, speculation, etc.),
- Importance of energy efficiency in making construction decisions,
- Methods used to evaluate energy efficiency improvements,
- Approaches to complying with Title 24 (performance v. prescriptive), and
- Sources of information on SDG&E's Savings Through Design Program.

For participants only, questions were also asked relating to the impact of the Program on efficiency choices. These questions were structured to allow the development of self-reported estimates of free ridership. Finally, for nonparticipants, questions were included to ascertain possible participation at sites other than the subject site. Copies of the Decision-Maker survey instruments are included in Appendix B. Appendix D contains a set of frequencies for the survey.

3.4 Other Data Collection

The following other kinds of data were also collected to support the analysis:

- ***Billing Data.*** Billing data were obtained from SDG&E for all participating and nonparticipating sites in the sample frames. These data were screened, inspected, and converted from billing cycle values to normalized (30.4 day) calendar month values. As noted earlier, considerable effort was expended to ensure that billing data matched the surveyed site. In cases where no such match was possible (primarily cases where the surveyed site was covered by a single large campus-style meter), billing data were set equal to missing.
- ***Weather Data.*** Weather data were collected for the period covered by the statistical analysis (1995 and 1996), as well as for a Typical Meteorological Year (TMY). The TMY data were later used in the DOE-2 analysis, while both TMY and actual 1995-6 weather data were ultimately used in the statistical analysis.
- ***Other Program Information.*** Participant lists from SDG&E's other nonresidential programs were collected in order to assess the possible impacts of these programs on efficiency levels at surveyed sites. Participant lists were provided by SDG&E for all nonresidential Energy Efficiency Incentive programs. These lists were cross-referenced against the list of surveyed sites to identify any potential cross-program effects, and a variable representing participation in other programs was incorporated into the net-to-gross analysis.

4

Building Simulation and Engineering Analysis

4.1 Introduction

This section describes the building simulation and engineering analysis used to develop initial estimates of DSM measure savings. Building simulation analyses were conducted using the SITEPRO software system for all members of the on-site sample, both participants and nonparticipants. SITEPRO utilizes DOE-2 to model building HVAC loads and energy use, and well tested engineering algorithms for estimating non-HVAC energy use. For this project, simulations were developed under two basic scenarios:

- ***Scenario A: As-Built and Operated Case.*** Under this scenario, all DSM measures (both those incented through the program and those installed outside of the program) were assumed to be in place.
- ***Scenario B: Reference Case.*** This scenario assumes strict compliance with Titles 20 and 24 where applicable, and other reference conditions where an end use is not covered by Code. For cases where the site participated in a remodel or tenant improvements, only those aspects of the site covered by codes were set to these reference conditions; others were kept at their as-built values.

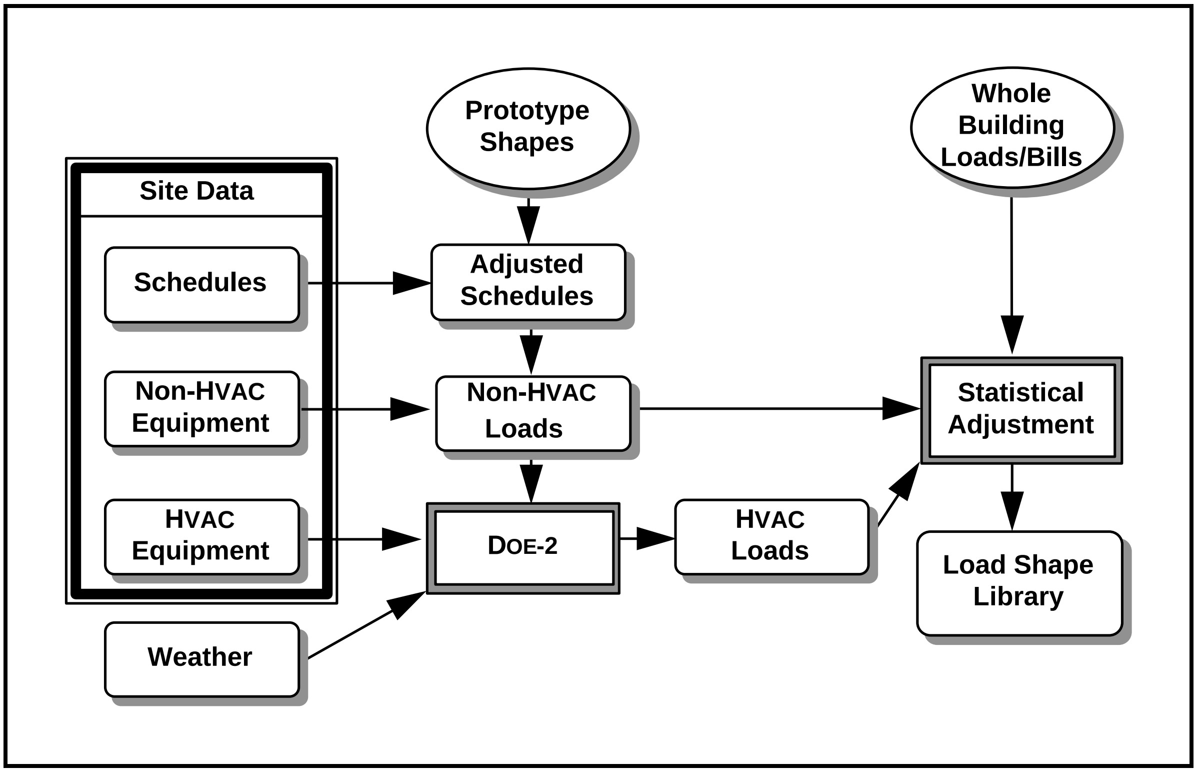
The difference between Scenario A and Scenario B was interpreted as an engineering estimate of total DSM savings.

The remainder of this section provides additional detail on SITEPRO, weather data used in the simulations, the assumptions used in the analysis of specific end uses and measures, and simulation results.

4.2 Overview of SITEPRO

The SITEPRO software is the best energy analysis system for utility survey data that is available in the industry today. It utilizes the industry's leading building simulation model (DOE-2) to estimate HVAC loads and energy use, and it utilizes well tested algorithms for estimating non-HVAC energy use. SITEPRO provides a framework for translating data about an individual site into reliable estimates of end-use loads for that site. This framework is illustrated in Figure 4-1, which is extracted from the *SITEPRO User's Guide*, a copy of which is provided in Appendix E.

Figure 4-1: SITEPRO Analysis Framework



Data used in SITEPRO include information on:

- Customer operations, including operating schedules and number of employees, and occupancy schedules,
- End-use equipment, including equipment counts, connected load estimates, equipment schedules, and hours of use, and
- Building geometry and thermal shell characteristics.

SITEPRO was executed in two steps as described below.

- In the first step, information about equipment inventories is combined with operating schedule data to develop hourly load profiles by day type for the non-HVAC end uses. Separate algorithms are applied for inside lighting, outside lighting, water heating, cooking, refrigeration, motors, air compressors, process equipment, office equipment, and miscellaneous equipment loads. These algorithms have been refined over the last five years with the help of industry experts and with reference to end-use metered data, where available.

- In the second step, HVAC loads are developed using the following information:
  - Thermal shell data,
  - HVAC system data,
  - Heating and cooling plant data,
  - Occupancy profiles, and
  - Usage profiles for lighting and other equipment.

  Based on these inputs and hourly weather, SITEPRO executes DOE-2 to estimate heat flows and energy usage on an hourly basis. The development of DOE-2 inputs from the survey data has been reviewed by developers of DOE-2 and by several experts in the area of building simulation using DOE-2.

SITEPRO performs a full hourly simulation (8,760 hours) for each end use. These results are summarized in 48-day format, defined by four daytypes in each month. The simulation results were compiled in a SAS database for use in the subsequent analysis.

It should be noted that SITEPRO has an additional feature which allows estimated loads to be calibrated to billing data on a site-by-site basis. This feature was not used in this study. However, a variety of reasonableness checks on the simulations were conducted. When large discrepancies between billed consumption and simulated usage occurred, or when simulated end use consumption seemed anomalous, assumptions were reviewed and further error checking was conducted. In some cases, survey information was refined through additional site visits. The reason for not calibrating as-built simulations against bills is that the realization rate analysis must be conducted with uncalibrated simulation results if the adjustment coefficients are to reflect engineering biases in estimating base usage and DSM savings. Indeed, the realization rate analysis can be considered a final calibration step. It is superior to site-by-site mechanical calibration because it can be used to differentiate between types of engineering biases as well as to yield insights on the sources of these biases (as represented by the arguments of the adjustment functions).

4.3 Weather Data

Typical meteorological year (TMY) weather data files were used for the DOE-2 simulation modeling. TMY data contain hourly data on various weather related variables including dry bulb temperature, humidity, wind speed, and actual measured solar insolation. In particular, all simulations used 1988 weather data to represent TMY as per SDG&E staff. Because DOE-2 can not handle leap years, this data was further manipulated by deleting the data for February 29th and using a calendar year of 1983 for the DOE-2 runs. Two weather stations, the only ones for which the complete set of data required to run DOE-2 were available, were used and mapped to SDG&E climate zones as follows:

- ***San Diego (Lindbergh Field).*** This weather station was used for all Maritime climate zones.
- ***NAS Miramar.*** This weather station was used for Coastal and Transition climate zones.

Individual sites were assigned to these stations on the basis of a ZIP code mapping provided by SDG&E.

4.4 Specific Simulation Assumptions

Interior Lighting

As-Built Simulations. As-built simulations of interior lighting loads were conducted using information on connected loads, operating hours, and lighting controls. Assumptions on these features were determined as follows:

- ***Connected Loads.*** Connected loads for each lighting system were developed by utilizing a SITEPRO technical data table, which is a lookup table that keys off lamp type, lamp watts, tube diameter, tube length, ballast type, and number of lamps per fixture. This technical data table was derived from the *Lighting Handbook*[1] developed by the CEC, previous survey data information, and IES lighting handbooks. All lighting systems collected in the survey data were mapped to this technical data table to determine system watts. For those systems that did not match up to an existing system in the technical data table, one of two actions was taken: either the survey data were changed to map the typically errant lighting system to one in the table; or, in rare cases, a new entry was added to the technical data table
- ***Operating Hours.*** Operating hours were set on the basis of lighting and operating schedules reported in the on-site survey.
- ***Lighting Controls.*** Dimmers, occupancy sensors, and daylighting controls were simulated by applying a usage-factor to the average weekly hours. These usage factors were derived from numbers obtained from Lawrence Berkeley Laboratory results/recommendations.[2] The algorithm used was as follows:
  - For dimmer-controlled lighting systems a 0.8 factor was applied to the average weekly hours.
  - For daylighting-controlled lighting systems a 0.65 factor was applied to the average weekly hours.

---

1 Advanced Lighting Guidelines, Second Edition, California Energy Commission, March 1993

2 Technology Data Characterizing Lighting in Commercial Buildings: Application to End-Use Forecasting with COMMEND 4.0 (Draft), Lawrence Berkeley Laboratory Energy Analysis Program, Energy and Environment Division, June 1993

- For occupancy sensor-controlled lighting systems the usage factor varied by building type as follows: Retail/Grocery/Restaurant/Lodging = 0.6, School = 0.8, Warehouse = 0.5, all other = 0.7.

Baseline Simulations. Baselines were defined to reflect strict adherence to Title 24 lighting densities in applicable areas and for applicable lighting systems. The process through which this was accomplished is described below:

- Use codes were verified, with special attention to the designation of lighting fixtures to display or advertising uses, which are exempt from Title 24 density limits.
- Densities for display, advertising, and exit lighting were maintained at their as-built levels.
- Densities in non-exempt lighting systems (area and task lighting) were set equal to their Title 24 maximum values and entered into a "Title 20 Allowed W/ft^2" table. This table, located in the survey database, contains default W/ft^2 values by Area ID based on the Title 24 Area Category Method (ACM).[3] These default values were generated from a map of RER space usage areas to Title 24 ACM Primary Function areas, but were redefined by the reviewer if necessary based on the description of the site and/or space activity area.
- In some cases, the survey covered areas other than those directly affected by the new construction, remodel, or tenant improvement in question. Lighting in these "untreated" areas was considered exempt from the Title 20 standards, and was left at its as-built density. As-built densities were also retained for some areas where the "treated" status of the lighting systems was indeterminate, as indicated by a W/ft^2 value that exceeded the Title 24 prescriptive values.

General HVAC System Strategy

As-Built and Baseline Simulations. Several simulation issues apply to all HVAC systems, as detailed below:

- ***Predominant HVAC System Type.*** In the SITEPRO/on-site survey system, HVAC systems were assigned to the "space usage areas" (i.e., Office, Warehouse, Retail, etc.) they serve, rather than to the exact thermal zones they serve. This was done to make the survey more manageable. However, the result of this simplification is that a "predominant" HVAC system type had to be selected from all those serving each space usage area. This was driven by the DOE-2 requirement that only one system type can serve a zone. SITEPRO logic determined the predominant system and created a composite HVAC system to represent all

[3] Energy Efficiency Standards for Residential and Nonresidential Buildings, California Energy Commission, July, 1995.

systems serving each space usage area. This method has been shown to yield satisfactory HVAC simulation results in previous survey/simulation projects.

As a result of this process, the As-Built/Baseline simulations for some high-efficient equipment may not have predicted all the savings expected, especially where the incented systems were mixed in with existing, older, less-efficient systems. The high-efficiency values may have been diluted or lost completely because package systems were not modeled individually. However, if the incented systems were negligible enough to not be selected as the predominant system, then these results are probably valid.

- ***Focus on Newer Systems.*** Special attention was paid to systems installed in or after 1994. That is, attention was paid to checking and obtaining proper capacities, efficiencies, and economizer status. Systems older than this were allowed to default to DOE-2 default values. For these newer systems, efficiency data were checked to ensure that each new system had only one as-built and one baseline value for efficiency.

Package HVAC Systems

Simulations of package HVAC systems utilized information on system type, cooling and heating equipment sizes and efficiencies, outside air percentages, thermostat settings and controls, economizers, and Title 24 minimum requirements, as described below:

- ***System Type.*** Survey data identifying the type of distribution system, cooling source, and heating source for each package unit were used in the simulations. SITEPRO is capable of modeling all major system types recognized by DOE-2.
- ***Make-Up Air Units.*** These units were identified in the data as Package Unit Ventilators (PUV) with no heating source, no cooling source, and 100% outside air.
- ***Cooling and Heating Equipment Sizes.*** Cooling and heating capacities taken directly from the survey data were used in the simulations. Missing capacities were autosized by DOE-2 via SITEPRO.
- ***Thermostat Settings.*** Thermostat settings were obtained from cooling and heating schedules specified in the on-site survey.

As-Built Simulations. For package systems, typically only the cooling efficiency, the heating efficiency, and the economizer status were changed from the as-built to the baseline run. Assumptions on these features were as follows:

- ***Cooling Efficiencies.*** The efficiencies reported on the survey were used unless they were below code or obviously errant data. For systems with a cooling capacity less than 65 kBtuh, if both an EER and a SEER were reported the one that was the most consistent with Title 24 was used and the other one deleted from the data. For those systems of 1994 or later vintage, if the efficiency was missing or less than the Title 24 minimum, correct values were obtained from one of the following:

- SDG&E contract materials (if HVAC equipment was incented)
- CEC Appliance[4] database
- Title 24 minimums, especially if equipment was not incented

Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.

- ***Heat Pump Heating Efficiencies.*** Only heat pump heating efficiencies were of concern, since their efficiencies are covered by Title 24. The COP rating at 47ºF[5] was used for DOE-2 simulations (there are two ratings in the standard, the other is at 17ºF). Efficiencies reported on the survey were used unless they were below code or inconsistent with the Title 24 COP at 47ºF. For systems with a cooling capacity less than 65 kBtuh, if both an HSPF and a COP were reported the one that was the most consistent with Title 24 was used and the other one deleted from the data. For those systems of 1994 or later vintage, if the efficiency was missing or less than the Title 24 minimum, correct values were obtained from one of the following:
  - SDG&E contract materials (if HVAC equipment was incented)
  - CEC Appliance database
  - Title 24 minimums, especially if equipment was not incented

  Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.
- ***Economizer Status.*** If the cooling capacity was greater than 75 kBtuh, an economizer was automatically imposed to satisfy the Title 24 requirement.

Baseline Simulations. Baselines were defined to reflect strict adherence to Title 24 minimum efficiencies by system type and economizer requirements. General baseline assumptions were as follows:

- ***Cooling Efficiencies.*** For systems of 1994 vintage or later, the Title 24 minimum efficiencies for a given equipment type, cooling capacity, and electrical phase were used. For systems with a cooling capacity less than 65 kBtuh, an efficiency value corresponding to the one used for the As-Built run was used, i.e., if an EER (instead of a SEER) was used for the As-Built run then an EER was used for the Baseline run as well. Baseline efficiencies were substituted directly into the original data table containing the package information. Circa 1993 and older systems with missing efficiencies were left blank, and SITEPRO defaulted them to DOE-2 default efficiencies.

[4] California Energy Commission Appliance Bulletin Board Service Survey.

[5] Per conversations with Steve Taylor, P.E. of Taylor Engineering, January 1997.

- ***Heat Pump Heating Efficiencies.*** For systems of 1994 vintage or later, the Title 24 minimum efficiencies (COP rating at 47ºF not 17ºF) for a given equipment type, cooling capacity, and electrical phase were used. For systems with a cooling capacity less than 65 kBtuh, an efficiency value corresponding to the one used for the As-Built run was used, i.e., if a COP (instead of an HSPF) was used for the As-Built run then a COP was used for the Baseline run as well. Baseline efficiencies were substituted directly into the original data table containing the package information. Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.
- ***Economizer Status.*** For units with economizers and a cooling capacity less than 75 kBtuh, the economizers were switched off, since economizers are not required on this size unit by Title 24.

Built-up HVAC Systems

Simulations of built-up cooling systems utilized information on system type, cooling and heating equipment sizes and efficiencies, and thermostat settings and controls, as described below:

- ***System Type.*** SITEPRO is capable of modeling all major system types recognized by DOE-2. Survey data identifying the type of distribution system, cooling source, and heating source for each package unit were used in the simulations.
- ***Cooling and Heating Equipment Sizes.*** Cooling and heating capacities direct from the survey data were used in the simulations. Missing capacities were autosized by DOE-2 via SITEPRO.
- ***Thermostat Settings and Controls.*** Thermostat settings were obtained from cooling and heating schedules specified in the on-site survey.

As-Built Simulations. For built-up systems, typically only the chiller efficiency, VAV system measures, and ASD/VSD pump controls were changed for the As-Built to Baseline run. Assumptions on these features were as follows:

- ***Chiller Efficiencies.*** The efficiencies reported on the survey were used unless they were below code or obviously errant data. For systems where both a kW/ton and a COP efficiency were reported the one that was the most consistent with Title 24 was used and the other one deleted from the data. For those systems of 1994 or later vintage, if the efficiency was missing or less than the Title 24 minimum, correct values were obtained from one of the following:
  - SDG&E contract materials (if HVAC equipment was incented)
  - Title 24 minimums, especially if equipment was not incented

  Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.

- ***VAV Distribution System Measures.*** For participants, a variable air volume (VAV) system consistent with SDG&E contractual materials was simulated, including any and all fan controls noted therein. In some instances, survey data was updated to be consistent with these materials. For the one nonparticipant that reportedly converted from Constant Volume (CV) to VAV, we simulated a VAV system consistent with the configuration and controls as noted on the survey form.
- ***ASD/VSD Circulation Pumps.*** These effects were simulated in DOE-2 by specifying the control of the circulation pumps as VSD in the survey data.

Baseline Simulations. Baselines were defined to reflect strict adherence to Title 24 minimum efficiencies. System type changes and ASD/VSD fan and pump changes were made consistent with SDG&E contract materials. General baseline assumptions were as follows:

- ***Chiller Efficiencies.*** For those chillers of 1994 or later vintage, the Title 24 minimum efficiencies based on chiller size and type were used. Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.
- ***VAV Distribution System Measures.*** For participants, the baseline run was made consistent with the SDG&E contractual materials; if a CV system was assumed as the baseline system by SDG&E, a CV system was assumed as the baseline here. If only VAV system controls were assumed (i.e., typically VSD fan control), only the fan control type was changed for the baseline run. For nonparticipants a Constant Volume (CV) system was simulated per survey data.
- ***ASD/VSD Circulation Pumps.*** These pumps were baselined by switching the control of the circulation pumps from VSD to single speed via the survey data for the baseline run.

Building Shell

As-Built Simulations. The only building shell measures addressed were external walls and roofs insulated to exceed Title 24 prescriptive requirements and window tinting. The information from the survey form used for this simulation included a noted observation of above-code external wall or roof insulation and the associated R-values, and an observation of window tinting and the associated tint type on the glazing. Assumptions on these features were as follows:

- ***External Wall Insulation.*** Effects of external wall insulation were simulated only if it was reported as a measure and R-values were indicated on the survey form. The R-value reported in the survey form was used for the as-built run. If an R-value was not reported then the effects of this measure were not simulated.

- ***Roof Insulation.*** Effects of roof insulation were simulated only if it was reported as a self-reported measure and R-values were indicated on the survey form. The R-value reported in the survey form was used for the as-built run. If an R-value was not reported then this measure was not simulated.
- ***Window Tint.*** Effects of window tint were simulated only if reported as a self-reported measure, the building was older than 1994, and the tint was installed in 1994/1995 or the window tint was incented. The assumption here was that if it was a new building then tint was probably required by code or at least part of the original Title 24 calculations and hence not a real measure. A glass type of tinted (=T) was used for the As-Built runs. If window tint was reported as a measure but the glass type was not recorded as tinted, it was changed to tinted.

  The best way to determine whether or not window tint was required was to look at the Relative Solar Heat Gain (RSHG) values allowed by the standard, then determine from these values what the minimum allowable glazing configuration might be.[6] Since the values of this parameter for Climate Zones 6-10 and 11-13 (San Diego areas) of 0.71 and 0.57, respectively, are consistent with tinted/reflective windows, one might assume that tinted windows were the base. However, the RSHG can be lowered via overhangs/fins such that a clear glass window could actually meet the standard (and there are in fact many such sites in the survey). In lieu of this fact, the approach taken seemed the most reasonable one.

Baseline Simulations. Baselines were defined to reflect strict adherence to Title 24 prescriptive requirements for external wall and roof insulation. Assumptions on these features were as follows:

- ***External Wall Insulation.*** The baseline value used was either R-11 (for Zones 6-10 which covered most San Diego areas) or R-13 (for Zones 11-13 , the transition-desert regions).
- ***Roof Insulation.*** The baseline value used was either R-11 (for Zones 6-10 which covered most San Diego areas) or R-19 (for Zones 11-13, the transition-desert regions).
- ***Window Tint.*** For the baseline run glass type was changed to clear (=C) in the survey data.

Remote Refrigeration

As-Built and Baseline Simulations. Remote refrigeration is not simulated by DOE-2. Instead, remote refrigeration load shapes[7] and on-site data were used to estimate energy use. In particular, the daily profile (hourly fraction for a typical day in each month) and daily energy use (kWh/day/kBtuh of case load) were combined with case loads (kBtuh) based on

[6] Per conversation with Steve Taylor, P.E. of Taylor Engineering, January 1997.

[7] These load shapes were developed by Doug Scott of VaCom Technologies and based on TMY weather for San Diego.

the refrigerated case and walk-in inventories (lineal ft, ft^2, or number of glass doors) at a site, to yield energy use. Assumptions on these features were as follows:

- ***Compressor, Condenser, and Associated Measures.*** For participant sites where the refrigeration measures were typically well documented, as-built and baseline runs were made consistent with the "Refrigeration Energy Savings Alternatives"[8] reports obtained from the SDG&E contract materials. This is a detailed report that analyzed the different options available to a remote refrigeration user, as well as defining a "baseline system" to which the various options were compared. This baseline system was typically (although not always) an air-cooled, multiplex system without any subcooling or floating head pressure (FHP) control. For nonparticipants, whenever remote refrigeration system measures were identified, an air-cooled, multiplex system without any subcooling or FHP control was assumed.
- ***Defrost Measures.*** Gas defrost systems, wherever noted as a measure, were switched to electric defrost for the baseline run.
- ***Case Measures.*** The only measure included here were high-efficiency case fans which were not simulated in SITEPRO.

Motors

As-Built and Baseline Simulations. Simulations of motors utilized information on motor size, efficiency type, and control type. Assumptions on these features were as follows:

- ***High-Efficiency Motors.*** SITEPRO utilized a motor technical data table to obtain efficiency as a function of a motor's horsepower (hp), and its efficiency type (standard or high-efficiency) as identified in the survey data, and its load factor (which was a default keyed off of the motor service type). However, these data only applied to motors entered in the *Motors/Engines* table of the survey form. For the as-built run, the "High-Efficiency" data field is set to "Y", and changed to "N" for the baseline run. For sites utilizing high-efficiency motors not entered on the *Motors/Engines* table (i.e., site RP216) the technical data table was simply utilized to "adjust" the effective motor hp to reflect these higher efficiencies (the only way to do this in SITEPRO).
- ***ASD/VSD Motors.*** ASD/VSD control is simulated via the *PartLoadElasticity* field in another SITEPRO technical data table. This is an exponential value (α) to which the load factor is raised which describes the shape of the load-factor versus kW-draw curve and it is used to determine energy use. A motor control type of *Electronic VSD (E)* used for the As-Built run was switched to a control type of *On/Off Switch (S)*.

[8] These reports were prepared by VaCom Technologies for SDG&E to evaluate refrigeration alternatives for specific sites.

- ***CO Sensors.*** There was only one site in the surveyed sample that had these controls installed and no real good way to simulate the savings from them, so no attempt was made to determine savings.

4.5 Results

Simulated End-Use Intensities

Table 4-1 summarizes the results of the engineering analysis. It depicts simulated end-use intensities, as well as estimated savings, for both participants and nonparticipants. As shown, baseline usage is very similar for participants and nonparticipants. Savings are higher for participants than for nonparticipants for every end use other than space heating. The reason for this latter result is that space heating savings include the adverse heating impacts (penalties) of lighting savings. Insofar as lighting savings are considerably higher for participants than for nonparticipants, these heating penalties are also higher. Virtually no program measures were found with direct favorable effects on space heating.

Table 4-1: Simulated End-Use Intensities (kWh/ft^2)

	Surveyed Participants			Surveyed Nonparticipants		
End Use	**Title 20/24**	**As-Built**	**Savings**	**Title 20/24**	**As-Built**	**Savings**
Interior Lighting	7.790	5.597	2.193	6.405	5.237	1.168
Space Cooling	4.686	4.095	0.591	3.275	2.996	0.279
Space Heating	0.249	0.309	-0.060	0.126	0.129	-0.003
Ventilation	2.363	2.274	0.089	2.029	2.017	0.012
Refrigeration	3.466	3.129	0.337	4.332	4.330	0.002
Process	1.532	1.375	0.157	2.102	2.083	0.019
Other	3.617	3.617	0.000	5.059	5.059	0.000
All End Uses	**23.731**	**20.424**	**3.307**	**23.334**	**21.856**	**1.478**

Simulated Monthly Baseline and As-Built Usage

Figure 4-2 and Figure 4-3 illustrate the monthly patterns of baseline and as-built consumption for participants and nonparticipants. As shown, the gap between these estimates—monthly savings—appears to be relatively constant across months. This reflects the dominance of lighting measures within the program.

Figure 4-2: Simulated Baseline and As-Built Usage - Participants

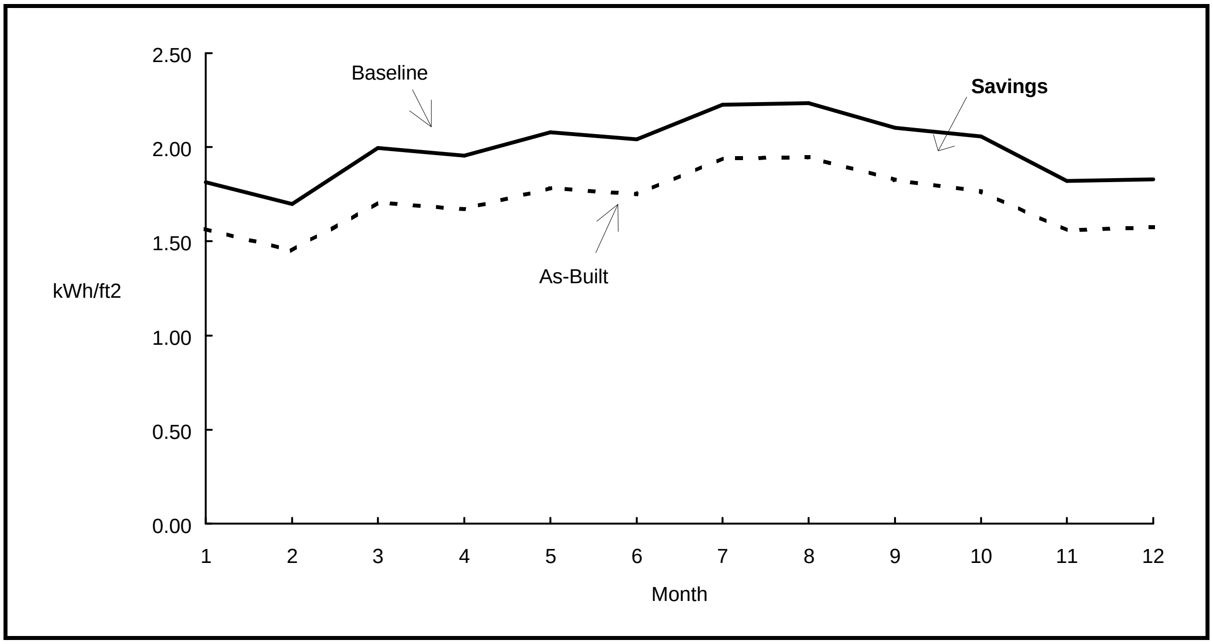


Figure 4-3: Simulated Baseline and As-Built Usage - Nonparticipants

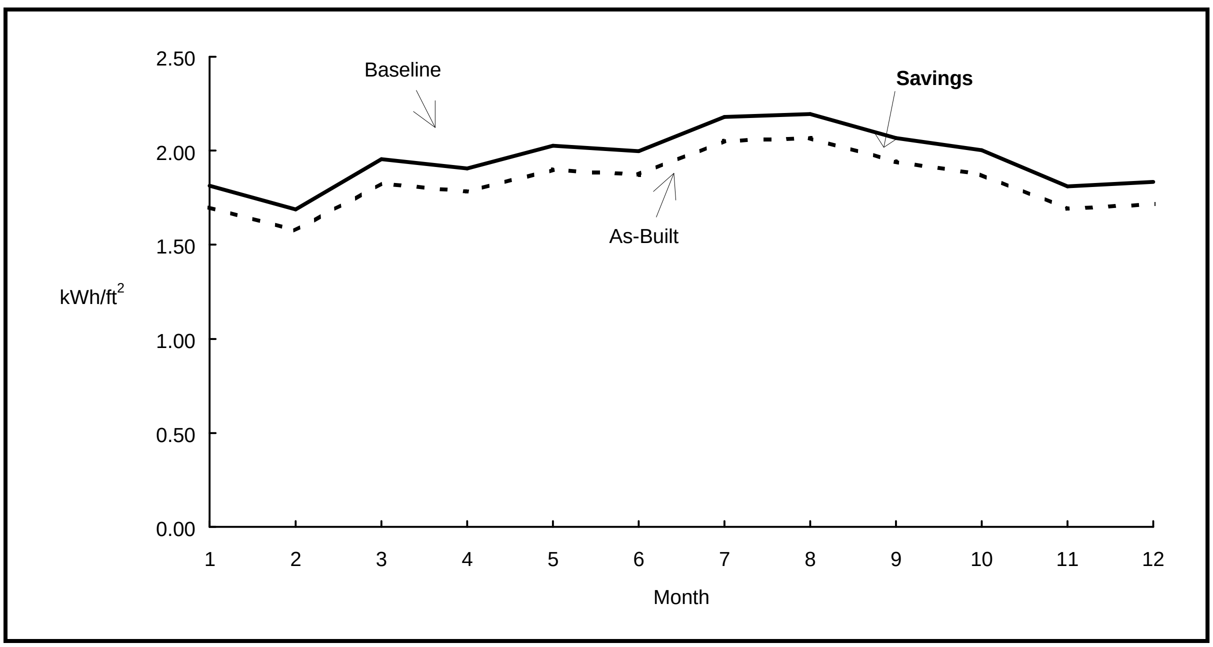
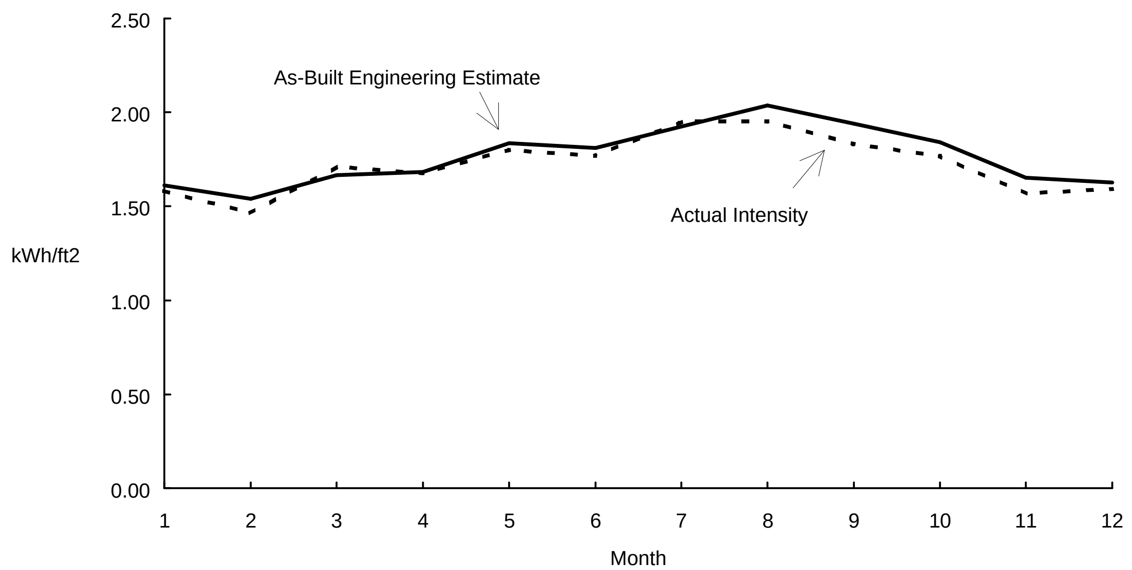


Figure 4-4 depicts the relationship between actual whole-building intensities and the as-built simulated intensities for the overall sample. Of course, discrepancies between as-built and actual intensities are obviously found at the individual site level. On the whole, however, the as-built simulations track actual usage reasonably well, although they tend to overstate usage in the summer months to some extent. This is a common result for simulation analysis, and traces to the fact that survey information on cooling practices can lead to overstatements of simulated loads. The correspondence between as-built and actual intensities suggest that the realization rate analysis should not cause major changes in the estimates of gross savings.

Figure 4-4: Actual Intensity Vs. As-Built Engineering Estimate - All Sites



Simulation Estimates of Total Program Savings

Table 4-2 summarizes the simulation estimates of total program savings. Two sets of estimates are provided. The first relates to the sample of 252 participating sites used for this analysis.[9] The second is expanded to represent the full program, which had 285 participants. For the 252 sites subjected to simulation analysis, total savings amounted to over 31.4 GWh. This estimates was expanded to the population using SDG&E's program estimates of savings for simulated and non-simulated sites. This approach is appropriate because the composition of the non-simulated sites was very different from that of the simulated sites. This was not a flaw in the sample design, given that a census was attempted. It resulted primarily from the refusal of several sites with extremely large estimated savings per square foot to allow the on-site survey. According to SDG&E program estimates, savings per square foot of the non-simulated sites was 4.48 kWh per square foot and 391,383 kWh per site, while the program estimate of savings for simulated sites was 2.82 kWh per square foot and 106,393 kWh per site. Clearly, expanding the simulation results by square foot or number of sites would be inappropriate. The expansion factor for energy savings was computed as:

[9] Note that one site had to be dropped from the engineering analysis because RER had no way of simulating its savings without conducting an additional survey of several hundred thousand square feet. By the time this was realized, it was considered too late to revisit the site.

$$\text{Expansion Factor for Savings} = \frac{\text{SDG\&E Estimate of Total Program Savings}}{\text{SDG\&E Estimate of Savings for Surveyed Sites}} = 1.483$$

The application of this factor to simulated savings resulted in an estimate of 46.570 GWh in savings for the overall program. A similar factor was used to expand total square footage of the surveyed sites to the population of participants. This factor, which was the ratio of SDG&E's estimate of square footage for all participants, divided by SDG&E's estimate of square footage for the surveyed sites, was determined to be 1.304.

Table 4-2: Summary of Simulation Estimates of Program Savings

End Use	Engineering Estimates for Surveyed Sites	Engineering Estimates for All Participants
Total Savings (GWh)		
Interior Lighting	20.840	30.885
Cooling	5.612	8.317
Heating	-0.569	-0.843
Ventilation	0.845	1.252
Refrigeration	3.206	4.751
Process and Other	1.490	2.208
Total Whole Building	**31.424**	**46.570**
Square Feet	**9,500,668**	**12,388,871**
Savings per Square Foot (kWh)		
Lighting	2.194	2.494
Cooling	0.591	0.672
Heating	-0.060	-0.068
Ventilation	0.089	0.101
Refrigeration	0.338	0.384
Other	0.157	0.178
Total Whole Building	**3.308**	**3.761**
Savings per Participant (kWh)		
Lighting	82,698	108,368
Cooling	23,270	29,182
Heating	-2,258	-2,959
Ventilation	3,353	4,394
Refrigeration	12,722	16,671
Other	5,913	7,748
Total Whole Building	**125,190**	**163,405**

Two central points should be made with respect to this simulation estimate of gross program savings.

- First, the engineering estimates contained in Table 4-2 are not directly comparable to SDG&E's estimate filed with its first year earnings claim, because it covers all savings estimated for participants, not just savings from incented measures. As such, it is much more broadly defined than SDG&E's *ex ante* savings estimate. However, this broadening of the savings estimate will be adjusted in the net-to-gross analysis, where participant savings are compared against savings experienced by nonparticipants using the same standards. The reason for this approach is that it is virtually impossible to disaggregate lighting savings from program and non-program measures if the correct baseline for savings is used. Title 24 lighting standards are written in terms of lighting densities, rather than the prescription of specific lighting types (although some lighting types are no longer permitted to be manufactured). Title 24 baselines were simulated by using the allowed densities for the space types in question. If a site has a density of, say, 20% below its Title 24 allowance, there is no good way to attribute this density reduction to incented and non-incentivized measures. Of course, it could simply be assumed that the incented measures were not in place. However, this requires the specification of a specific baseline lighting technology, and this approach can yield implausible results. For instance, using incandescent lighting as a baseline for compact fluorescents can grossly overstate savings because the lumen-equivalent incandescents could not be delivered without violating code densities.
- Second, because they are defined differently, RER's engineering estimates of savings should not be considered verification of SDG&E's approach to estimating program savings. On the contrary, RER's review of the program files revealed some major differences in the savings estimated for lighting and our estimates of total lighting savings relative to code. This was especially true when compact fluorescents were incented. For sites with predominantly compact fluorescent lighting and densities just qualifying for the program (10% below code), SDG&E's estimates were often an order of magnitude greater than calculations based on code. Of course, this was partly offset by cases where sites installed considerably less lighting than permitted by code without using a preponderance of incented high-efficiency lighting. In these cases, RER's estimates were sometimes considerably above SDG&E's. It is not clear what SDG&E should do in this area. One option is to check that the baseline technology used to compute savings would also satisfy Title 24, and to scale back estimates if this requirement is not satisfied.

5

Estimation of Gross Realized Savings

5.1 Introduction

While the simulation results were cross checked against billing data in order to identify data errors and/or mismatches between the surveyed site and the site covered by the billing data, even the final engineering estimates can be biased due to errors in reported schedules or other operating conditions. Moreover, engineering estimates ignore the possibility of rebound, or snap-back, effects as well as the possibility that engineering biases may differ across levels of efficiency. Although engineering estimates provide important information on gross program impacts, these estimates were further refined with a statistical adjustment process termed the realization rate approach.[10] The general realization rate framework is essentially a statistically adjusted engineering (SAE) approach designed to develop a set of calibration factors, or realization rates, on the engineering estimates of savings from both incentivized and non-incentivized measures. Two aspects of the analysis should be noted carefully. First, it should be recognized that the base for the realization rates developed in this chapter is the project team's engineering estimates of savings, not SDG&E's *ex ante* estimates. Second, it should be understood that the analysis yields estimates of gross realized (*ex post*) savings without regard to the reasons why these measures were installed.

In the rest of this section, the application of the realization rate approach to estimate gross realized program savings is described. Subsection 5.2 provides an overview of the realization rate approach. Subsection 5.3 discusses the specific realization rate model developed in this evaluation. Subsection 5.4 presents the estimates of gross realized program savings developed through the use of the model.

5.2 Overview of the Realization Rate Model

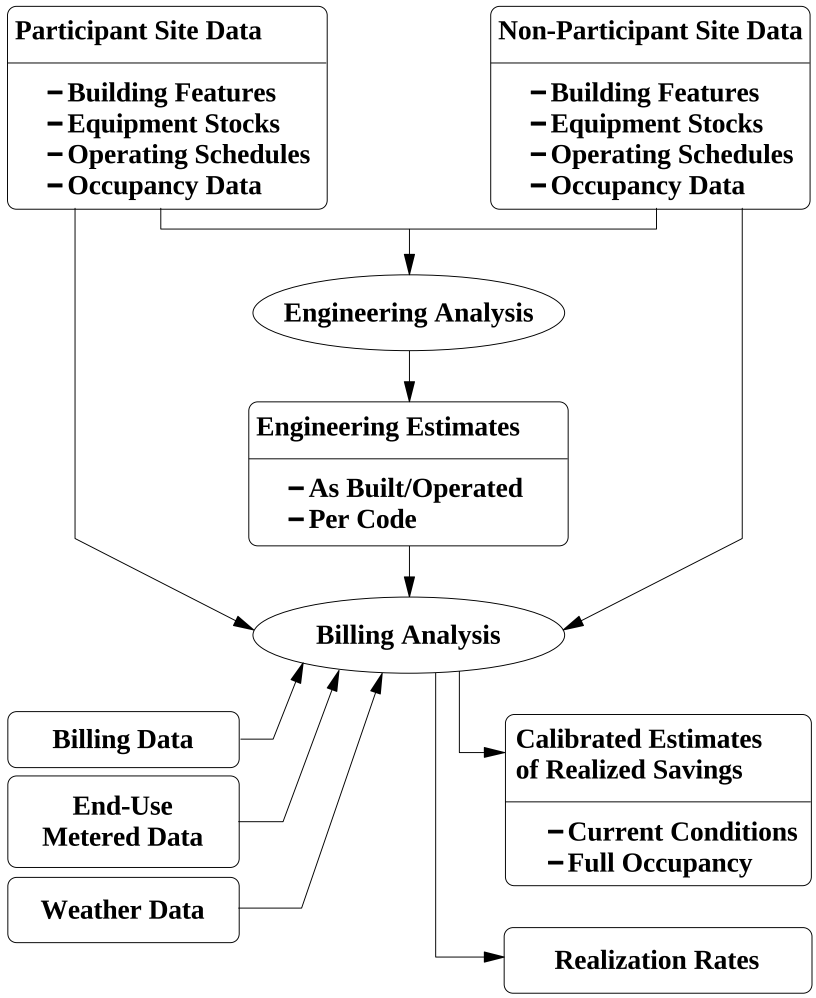
General Logic

The general logic of the realization rate approach (as applied to new construction programs) is illustrated in Figure 5-1. The first step of the analysis entails the development of engineering estimates of end-use consumption levels. As was discussed in Section 4, these

[10] For other applications of this approach, see Sebold and Fox, 1985; and Sebold, Wang and Mayer, 1995.

estimates are based on information about building features, equipment stocks, operating schedules, and occupancy data. As shown in Figure 5-1, the realization rate model relies on estimates of end-use consumption under two scenarios: the as-built scenario and the reference scenario, which entails minimal compliance with building standards. The model also makes use of information on site characteristics (e.g., square footage), as well as weather conditions and occupancy characteristics that might affect the realization of the engineering estimates of baseline usage and DSM-related savings. The model produces a set of adjustment coefficients (or adjustment functions) that translate these engineering estimates into estimates consistent with observed energy usage. These coefficients are called realization rates. As explained below, the realization rates on savings reflect the proportion of engineering-based savings estimates actually realized in the form of reduced site usage.

Figure 5-1: Overview of the Realization Rate Model



Model Specification

To derive the realization rate model, we begin with the standard statistically adjusted engineering (SAE) specification:

$$(1) \quad E_{bt} = \sum_{e} \alpha_e EEACTUAL_{bet} + \varepsilon_{bt}$$

where E_{bt} is whole-building energy consumption at site *b* in time *t*, and $EEACTUAL_{bet}$ is an engineering estimate of consumption through end use *e* at the site based on assumptions reflecting the actual design and operation of the building. The presence of the adjustment coefficient (α_e) reflects the possibility of general engineering bias. The model can be expanded by decomposing the engineering estimates into two elements:

$$(2) \quad EEACTUAL_{bet} = EEBASE_{bet} - EESAV_{bet}$$

where $EEBASE_{bet}$ represents an engineering estimate of usage under a baseline assumption with respect to the presence of energy conservation measures and $EESAV_{bet}$ represents an engineering estimate of savings from energy efficiency beyond the baseline. There are several ways of defining the baseline for savings. One option in this regard would be to let this estimate reflect minimal compliance with standards.[11] The specification shown in (2) simply splits the engineering estimate into a baseline estimate and an estimate of the savings associated with the energy conservation beyond baseline levels. Substituting (2) into (1), we obtain:

$$(3) \quad E_{bt} = \sum_{e} \alpha_e [EEBASE_{bet} - EESAV_{bet}] + \varepsilon_{bt}$$

Once the model is put into this form, possible modifications are apparent. First, the basic adjustment coefficient on the estimated energy savings should be allowed to be different from the adjustment coefficient of the baseline engineering estimate. Second, these adjustment coefficients should be permitted to vary across sites as conditions vary. One possible version of the revised model is as follows:

$$(4) \quad E_{bt} = \sum_{e} \alpha_e (X_{bt})[EEBASE_{bet} - \beta_e EESAV_{bet}] + \varepsilon_{bt}$$

where β_e is an adjustment coefficient reflecting the bias in engineering savings estimates *relative* to the bias in the baseline energy usage estimates. Note also that the overall

[11] As explained above, this reference scenario is only a reference point for the realized savings analysis. The true baseline for the overall program evaluation is the participant's usage in the absence of the program, and this may differ from the level associated with standards compliance.

adjustment coefficient ($\alpha_e(X_{bt})$) is assumed to be a function of relevant factors. These factors could include site characteristics, like occupancy rates, as well as weather, building category dummies, or other variables thought to affect the overall accuracy of baseline engineering calculations.

Estimation of the Realization Rate Model

The realization rate model can be estimated by applying regression analysis to data on a sample of sites for which billing data, comprehensive engineering estimates, and site data are available. For this study, the model was estimated using all sites for which DOE-2 analyses are conducted and for which comparable billing records were available. It is fairly common to encounter several statistical problems in the course of estimating this type of model, and it is important to deal with these effectively. Typical problems are discussed later in this section.

Use of the Model to Infer Realization Rates

Given this simple yet flexible framework, the end-use specific realized savings associated with differences between baseline efficiency levels and the levels of efficiency found in the buildings covered by the analysis would be:

$$(5) \quad REALIZED\ SAVINGS_{bet} = \hat{\alpha}_e(X_{bt})\ \hat{\beta}_e EESAV_{bet}$$

where $\hat{\alpha}_e$ is the estimated overall adjustment function for the site and end use in question and $\hat{\beta}_e$ is the estimated value of β_e. The associated realization rate can be defined as:

$$(6) \quad REALIZATION\ RATE_{bet} = \hat{\alpha}_e(X_{bt})\ \hat{\beta}_e$$

There are several points to note about this approach:

- It directly integrates the results of building simulations. To the extent that it takes advantage of the detailed information used as inputs into these simulations, it should increase the efficiency of the gross savings estimation process. This, of course, depends on the quality of the simulations, an issue that was addressed in Section 4.
- It is relatively efficient in preserving degrees of freedom (compared, for instance, to complex conditional demand models).
- It can be used to estimate realized savings for individual conservation measures or groups of measures, unlike approaches that focus on differences in energy usage between participants and nonparticipants.

- It is more amenable to the analysis of a heterogeneous set of program participants receiving a broad range of DSM measures than most other statistical approaches like conditional demand analysis.
- It can be used directly to weather-normalize realized savings. The approach used for this purpose is straightforward. Engineering estimates of base usage ($EEBASE_{bet}$) and DSM savings ($EESAV_{bet}$) are developed through DOE-2 simulations using normal weather conditions. Then, the general realization rate function ($a_e(X_{bt})$) is specified to contain terms representing the deviation of actual weather from normal weather in the billing period in question. This step accommodates the fact that billing data reflect actual weather conditions, whereas simulated usage estimates reflect normal weather. Once the realization rate function was estimated, the weather deviation is set to zero and the model is solved for the realization rate and the associated weather-normalized value of realized savings.
- Realization rates derived for a representative sample of participants are applicable to other participants for whom engineering estimates are similarly derived. Thus, these rates can be used to transform engineering estimates of overall gross program savings (adjusted for differences between evaluation engineering estimates and program estimates) into calibrated estimates of realized savings.

5.3 Savings Through Design Program Realization Rate Model

Model Specification

The specific model used in this realization rate analysis is a fairly simple form of the general model presented above. The model is given by:

$$
\begin{aligned}
(7)\quad E_{bt} &= b_0 + b_1 EET24LT_{bt} + b_2 EEELTSAV_{bt} + b_3 EET24HT_{bt} \\
&+ b_4 EET24HT_{bt} HDDRAT1_{bt} + b_5 EET24HT_{bt} HDDRAT2_{bt} + b_6 EEHTSAV_{bt} \\
&+ b_7 EEHTSAV_{bt} HDDRAT1_{bt} + b_{87} EEHTSAV_{bt} HDDRAT2_{bt} + b_9 EET24CL_{bt} \\
&+ b_{10} EET24CL_{bt} CDDRAT1_{bt} + b_{11} EET24CL_{bt} CDDRAT2_{bt} + b_{12} EECLSAV_{bt} \\
&+ b_{13} EECLSAV_{bt} CDDRAT1_{bt} + b_{14} EECLSAV2_{bt} CDDRAT_{bt} + b_{15} EET24VT_{bt} \\
&+ b_{16} EEVTSAV_{bt} + b_{17} EEBREF_{bt} + b_{18} EEREFSAV_{bt} + b_{19} EEPRAB_{bt} \\
&+ b_{20} EEEXLTAB_{bt} + b_{21} EECKAB_{bt} + b_{22} EECOOKAB_{bt} + b_{23} EEWHAB_{bt} \\
&+ b_{24} EEEQUAB_{bt} + b_{22} EEMISCAB_{bt} + m_{bt}
\end{aligned}
$$

where the following are engineering estimates based on the SITEPRO analysis:

$EET24LT_{bt}$	=	lighting usage per square foot under the Title 24 scenario
$EELTSAV_{bt}$	=	lighting savings relative to Title 24
$EET24HT_{bt}$	=	heating usage per square foot under the Title 24 scenario
$EEHTSAV_{bt}$	=	heating savings relative to Title 24
$EET24CL_{bt}$	=	cooling usage per square foot under the Title 24 scenario
$EECLSAV_{bt}$	=	cooling savings relative to Title 24
$EET24VT_{bt}$	=	ventilation usage per square foot under the Title 24 scenario
$EEVTSAV_{bt}$	=	ventilation savings relative to Title 24
$EEBREF_{bt}$	=	baseline refrigeration usage per square foot
$EEREFSAV_{bt}$	=	refrigeration savings relative to the baseline
$EEPRAB_{bt}$	=	process usage (process, water heating, compressors) under the as-built scenario
$EEEXLTAB_{bt}$	=	exterior lighting usage under the as-built scenario
$EECKAB_{bt}$	=	cooking usage under the as-built scenario
$EEWHAB_{bt}$	=	water heating usage under the as-built scenario
$EEEQUAB_{bt}$	=	office equipment usage under the as-built scenario
$EEMISCAB_{bt}$	=	miscellaneous usage under the as-built scenario

and where the weather terms are:

$HDDRAT1_{bt}$	=	deviation of actual heating degree-days from monthly normal degree-days, as a proportion of average annual normal heating degree days
$CDDRAT1_{bt}$	=	deviation of actual cooling degree-days from monthly normal values, as a proportion of average annual normal cooling degree days
$HDDRAT2_{bt}$	=	deviation of actual heating degree-days from *average* monthly normal degree-days, as a proportion of average monthly normal heating degree days
$CDDRAT2_{bt}$	=	deviation of actual cooling degree-days from *average* monthly normal values, as a proportion of average monthly normal cooling degree days

Note that the interaction of $HDDRAT1_{bt}$ and $CDDRAT1_{bt}$ with baseline usage and savings accounts for the fact that the engineering estimates were based on normal (TMY) weather, whereas actual space conditioning usage reflects actual weather. The expected sign of both of these terms is negative. The interaction of $HDDRAT2_{bt}$ and $CDDRAT2_{bt}$ with baseline usage allows the realization rate to vary across weather conditions. A positive sign indicates that actual cooling/heating loads are more sensitive to degree-days than the engineering estimates, while a negative sign indicates that actual loads are less sensitive than simulated loads.

In the course of model estimation, a number of additional variables were defined to account for shortcomings in the engineering estimates. These variables are as follows:

- Several site specific dummy variables were defined for sites with loads that had been identified but unquantified in the course of the survey. These loads included unsurveyed parking garage lighting (RP002, RP242), large pumping loads (RP602), pool pumping loads (RN159), campsite loads (RN164), unidentified cooking loads (RN444), open architecture (RP188), and unidentified cooking and miscellaneous loads (RP227 and RP248).
- Binary site variables were also defined to account for specific conditions at some biological or pharmaceutical labs: the presence of large humidifiers at some sites, and the presence of loads in areas that could not be surveyed. Three sites were affected: RP196, RP201, and RP216.

Estimation Database

The realization rate model was estimated by applying regression analysis to data on both participants and nonparticipants. A total of 411 surveys were completed, so these sites were candidates for the analysis. Some attrition in the sample was encountered, however. Four nonparticipant sites were excluded altogether from the engineering and statistical analysis because they did not really qualify as new construction, remodels, or tenant improvements. Moreover, billing data for the surveyed site were unavailable in 62 cases. This problem occurred when the surveyed site was a small part of the area covered by an account, and was fairly common in campus settings and some large high-rise office buildings. In another four cases, billing data were set equal to missing because they were incomplete (i.e., meters were judged to be missing). This left 349 sites with billing data to be used in the regression analysis.

The model was estimated with four types of data:

- ***Billing Data.*** Billing data for the most recent 13 months were used. However, one observation was lost for each site in the course of correcting for autocorrelation.
- ***Weather Data.*** Both actual and normal weather data were used for the same period of time. Weather was characterized in terms of heating- and cooling degree-days.
- ***Engineering Estimates.*** Engineering estimates of end use consumption under the as-built and the baseline scenarios were incorporated as regressors.

- ***Other Site Characteristics.*** Other site characteristics, most prominently square footage and building type, were also incorporated into the model.

Model Estimation

Several statistical problems can be encountered when estimating billing models like this one. These problems and their resolutions are discussed briefly below.

- ***Self-Selection Bias.*** Self-selection bias can be a problem in some load impact regression models containing a participation variable, but should not affect a realization rate model like the one to be used here. When the model contains one or more participation variables, the coefficients of these variables are meant to indicate the net impact of participation on energy usage, and their coefficients can be biased by the presence of self-selection bias. However, in the realization rate model, *ex ante* savings estimates from the adoptions of specific measures (by participants and nonparticipants) are included, rather than participation variables, and there is no reason for self selection to affect these coefficients. Self-selection bias will be addressed in Section 6, where the net impact of program participation on efficiency choices is assessed.
- ***Multicollinearity.*** Multicollinearity is an econometric problem arising from the correlation of explanatory variables with each other. In the presence of severe multicollinearity, it is difficult to statistically disentangle the separate effects of the offending (correlated) variables. In the context of this realized savings model, it was sometimes necessary to restrict some of the coefficients to mitigate collinearity.
- ***Autocorrelation.*** Autocorrelation (the correlation of site-specific residuals over time) can be a vexing problem in that it biases the standard errors downward and causes t-values to be overstated. A test for autocorrelation indicated its presence, and generalized least squares was used to mitigate the problem.
- ***Heteroskedasticity.*** Heteroskedasticity can also be troublesome in the analysis of nonresidential usage, partly because the scale of usage varies so sharply across sites. This problem was mitigated through the application of generalized least squares. The error variance was found to be positively correlated with site square footage, and the data were transformed by the appropriate power of this variable to mitigate the heteroskedasticity.
- ***Outliers.*** Residuals were reviewed extensively. Given the strong fit of the model, there were very few outliers. In general, these few extreme residuals arose from partial occupancy at the site, and occurred at the beginning of the consumption series for the sites in question. These specific monthly observations were set equal to missing for the realization rate analysis, although the rest of the monthly observations for the affected sites were used in estimation.

Model Results

Table 5-1 presents the estimated coefficients and standard errors for the realization rate model. Two versions of the model are presented, differing only in the use of parameter restrictions. These versions are discussed below.

Version 1. In Version 1, we simplify the model by assuming that there is no differential engineering bias between estimates of baseline usage and savings. This essentially means that we are assuming that β_e in equation (4) is equal to 1.0 for all end uses. These assumptions are imposed through a set of restrictions on the individual coefficients of the parameters of the model. Note that the parameter estimates for baseline and savings are equal (with a sign reversal) for all end uses in this version as a result of these restrictions. In this model, the coefficients on the free-standing savings terms can be interpreted as realization rates. The coefficients of the heating and cooling degree-day interaction terms can be ignored because these terms would be equal under normal weather conditions. As shown, the interior lighting savings coefficient is equal to 1.13, which indicates that engineering estimates of savings are fully realized in the form of reductions in energy usage. The same is true of process savings, which includes savings associated with air compressors, motors, and process heat, and which takes on a realization rate of 0.97. The relatively low realization rates on heating (0.887), cooling (0.825), and ventilation (0.655)are not completely unexpected. Similar results have been found in other studies. HVAC usage is often lower than engineering simulations would suggest, perhaps because of erroneous information on thermostat schedules. The refrigeration realization rate (0.788) may result from a general overestimate of refrigeration usage, and this may reflect the use of too high a diversity factor in the engineering calculations.

Version 2. In Version 2, we remove the parameter restriction on interior lighting, which accounts for 90% of SDG&E's claimed savings, and refrigerationOther end uses were left in the as-built form, for two reasons. First, cooling and heating savings are highly collinear with lighting savings, insofar as they are strongly affected by lighting HVAC interactions, and this leads to instability in their coefficients. Second, other end uses (e.g., process) have relatively low expected savings, and the associated realization rates on savings tend to lack robustness. As shown in Table 5-2, the realization rate on lighting is very stable, falling only slightly to 1.045. The realization rate on refrigeration, on the other hand, increases fairly substantially to 0.942. While both versions of the realization rate model yield very similar savings overall, Version 1 was chosen as the final version. This choice was made because of substantial difference in the coefficients on refrigeration base usage and refrigeration savings did not appear plausible. However, the results shown for Version 2 reinforce the general conclusions that lighting savings are slightly more than fully realized and that other savings have reasonably high rates of realization.

Table 5-1: Estimated Realization Rate Model (t-values in parenthesis)

Variable	Version 1	Version 2
$EET24LT_{bt}$	1.12895 (56.18)	1.11612 (47.28)
$EELTSAV_{bt}$	-1.12895 (56.18)	-1.04479 (16.06)
$EET24HT_{bt}$	0.88651 (5.20)	0.87675 (5.26)
$EET24HT_{bt}\ HDDRAT1_{bt}$	2.50296 (1.37)	2.52188 (1.41)
$EET24HT_{bt}\ HDDRAT2_{bt}$	-0.26080 (3.13)	-0.25827 (3.18)
$EEHTSAV_{bt}$	-0.88651 (5.20)	-0.87675 (5.26)
$EEHTSAV_{bt}\ HDDRAT1_{bt}$	-2.50296 (1.37)	-2.52188 (1.41)
$EET24HT_{bt}\ HDDRAT2_{bt}$	0.26080 (3.13)	0.25827 (3.18)
$EET24CL_{bt}$	0.82509 (31.22)	0.81677 (31.01)
$EET24CL_{bt}\ CDDRAT1_{bt}$	1.37184 (8.24)	1.35720 (8.26)
$EET24CL_{bt}\ CDDRAT2_{bt}$	-0.00514 (0.61)	-0.00574 (0.69)
$EECLSAV_{bt}$	-0.82509 (31.22)	-0.81677 (31.01)
$EECLSAV_{bt}\ CDDRAT1_{bt}$	-1.37184 (8.24)	-1.35720 (8.26)
$EET24HT_{bt}\ HDDRAT2_{bt}$	0.00514 (0.61)	0.00574 (0.69)
$EET24VT_{bt}$	0.65505 (34.29)	0.65463 (33.90)
$EET24VT_{bt}\ CDDRAT2_{bt}$	0.03201 (5.06)	0.03199 (5.04)
$EEVTSAV_{bt}$	-0.65505 (34.29)	-0.65463 (33.90)
$EEVTSAV_{bt}\ CDDRAT1_{bt}$	-0.03201 (5.06)	-0.03199 (5.04)
$EEBREF_{bt}$	0.78818 (60.01)	0.79839 (53.38)
$EEREFSAV_{bt}$	-0.78818 (60.01)	-0.94181 (8.02)

Table 5-1 (cont'd.): Estimated Realization Rate Model (t-values in parenthesis)

Variable	Version 1	Version 2
$EEPRT24_{bt}$	0.97345 (72.75)	0.97262 (71.75)
$EEPRSAV_{bt}$	-0.97345 (72.75)	-0.97262 (71.75)
$EEEXLTAB_{b}$	1.03322 (29.00)	1.02659 (27.51)
$EECKAB_{bt}$	1.02425 (81.41)	1.02311 (78.69)
$EEWHAB_{bt}$	2.32939 (9.85)	2.33976 (9.78)
$EEEQUAB_{bt}$	1.07807 (19.10)	1.07284 (19.10)
$EEMISCAB_{bt}$	1.45613 (33.60)	1.46059 (33.74)
$RP002_{bt}$	1.06048 (6.46)	1.04480 (6.36)
$RP242_{bt}$	1.07755 (8.89)	1.08406 (9.16)
$\mathrm{RP602}_{bt}$	1.54660 (12.35)	1.54084 (12.49)
RN159	0.49974 (3.83)	0.49070 (3.81)
RN164	1.43486 (10.94)	1.41901 (10.96)
RN444	1.36915 (3.91)	1.42283 (3.93)
RP188	0.86191 (5.97)	0.86810 (6.07)
RP227	1.18674 (10.33)	1.24967 (10.38)
RP248	0.93430 (3.48)	0.91473 (3.54)
RP201	2.46401 (10.66)	2.45642 (10.46)
RP196	1.53464 (11.87)	1.52169 (11.93)
RP216	0.88825 (8.02)	0.86591 (7.96)
Adjusted R^2	0.937	0.936

5.4 Estimated Gross Realized Program Savings

The results of the realization rate model (Version 1) can be used to generate estimates of realized savings for participants. For HVAC end uses, these estimates are designed to be weather normalized. This is accomplished by making the incremental weather terms ($HDDRAT1_{bt}$, $HDDRAT2_{bt}$, $CDDRAT1_{bt}$ and $CDDRAT2_{bt}$) equal to zero (indicating that under normal weather conditions, deviations from the TMY weather are assumed to be zero). The results of these calculations are shown below in Table 5-2. Realized savings estimates are presented in three forms: as total energy saved, energy savings per square foot of surveyed space, and energy savings per building. Gross realized savings are also presented for the full population of participants. These estimates were developed by using the ratio of total participant square footage to total surveyed square footage as an expansion factor.

As shown in Table 5-2, our engineering estimate of total energy savings for the participant sample amount to 46.78 GWh. Applying the end-use realization rates to the respective end-use engineering estimates, we obtain a total realized savings of 47.69. This implies an overall realization rate of 1.0195.

Table 5-2: Estimated Gross Realized Program Energy Savings

End-Use	Engineering Estimate of Program Savings	Estimated Realization Rate	Gross Realized Savings
Total Savings (GWh)			
Interior Lighting	30.885	1.129	34.869
Cooling	8.317	0.825	6.862
Heating	-0.843	0.887	-0.748
Ventilation	1.252	0.648	0.811
Refrigeration	4.751	0.788	3.744
Process	2.208	0.973	2.148
Total Whole Building	**46.570**	**1.024**	**47.686**
Savings per Square Foot (kWh)			
Interior Lighting	2.494	1.129	2.816
Cooling	0.672	0.825	0.554
Heating	-0.068	0.887	-0.060
Ventilation	0.101	0.648	0.065
Refrigeration	0.384	0.788	0.303
Other	0.178	0.973	0.173
Total Whole Building	**3.761**	**1.024**	**3.851**
Savings per Participant (kWh)			
Interior Lighting	108,368	1.129	122,347
Cooling	29,182	0.825	24,075
Heating	-2,959	0.887	-2,625
Ventilation	4,394	0.648	2,847
Refrigeration	16,671	0.788	13,137
Process	7,748	0.973	7,539
Total Whole Building	**163,405**	**1.024**	**167,321**

Table 5-3 depicts estimated demand savings. The peak fractions used to develop these estimates were derived from SitePro results. These peak fractions are:

- Interior Lighting: 0.00017
- Cooling: 0.00023
- Ventilation: 0.00015
- Heating: 0.00000
- Refrigeration: 0.00011
- Process: 0.00020

It was assumed that the energy realization rates also apply to demand savings. As indicated in Table 5-3, total realized demand impacts amount to over 8.4 MW, or just over 29.7 kW per building (per participant).

Table 5-3: Estimated Gross Realized Program Demand Savings

End-Use	Engineering Estimate of Program Savings	Estimated Realization Rate	Gross Realized Savings
Total Savings (MW)			
Lighting	5.250	1.129	5.928
Cooling	1.913	0.825	1.578
Heating	0.000	0.887	0.000
Ventilation	0.188	0.648	0.122
Refrigeration	0.523	0.788	0.412
Other	0.442	0.973	0.430
Total of All End-Uses	**8.315**	**1.019**	**8.469**
Savings per Square Foot (W)			
Lighting	0.424	1.129	0.479
Cooling	0.155	0.825	0.127
Heating	0	0.887	0.000
Ventilation	0.015	0.648	0.010
Refrigeration	0.042	0.788	0.033
Process	0.036	0.973	0.035
Total of All End-Uses	**0.672**	**1.019**	**0.684**
Savings per Participant (kW)			
Lighting	18.423	1.129	20.799
Cooling	6.712	0.825	5.537
Heating	0.000	0.887	0.000
Ventilation	0.659	0.648	0.427
Refrigeration	1.834	0.788	1.445
Other	1.550	0.973	1.508
Total of All End-Uses	**29.177**	**1.019**	**29.716**

The CPUC M&E Protocols require the specification of confidence intervals for both gross and net savings estimates. This is not a straightforward exercise when a realization rate model is specified with separate realization rates on individual end uses, insofar as the standard error of total realized savings depends on the variances and covariances of all of the estimated realization rates. Confidence intervals were developed for gross realized savings using the following approach:

- First, the realization rate model (Version 1) was re-estimated using a composite of all of the savings variables, each multiplied times its own coefficient from Table 5-1. That is, the composite (SAV_{bt}) was defined as:

  $$SAV_{bt} = \sum_k \hat{d}_k SAV_{kbt}$$

  where $\hat{d}_k$ is the estimated coefficient from Table 5-1 and SAV_{kbt} is the savings term for end use k. Of course, the expected coefficient of this composite variable is 1.0, since this form of the model is equivalent to Version 1.

- Second, the standard error of the composite variable, which is a relative standard error in the sense that the coefficient is normalized to 1.0, is used to develop a confidence interval for gross realized savings.

The results of this exercise are shown in Table 5-4.

Table 5-4: Confidence Intervals for Estimated Gross Realized Savings

Measure of Savings	Point Estimate	90% Confidence Interval	80% Confidence Interval
Gross Energy Savings			
Total Program (GWh)	47.686	43.943 - 51.429	44.772 - 50.600
per Square Foot (kWh/ft^2)	3.851	3.549 - 4.153	3.616 - 4.086
per Building (kWh)	167,321	154,186 - 180,456	157,098 - 177,544
Gross Demand Savings			
Total Program (MW)	8.469	7.804 - 9.134	7.952 - 8.986
per Square Foot (W/ft^2)	0.684	0.630 - 0.738	0.642 - 0.726
per Building (kW)	29.716	27.383 - 32.049	27.900 - 31.532

6

Estimation of Net Realized Impacts

6.1 Introduction

The net impacts of the program are the savings that can be attributed to the program. Estimating net impacts of new construction programs is a complex process. New construction programs are multi-dimensional, covering multiple end uses and a variety of DSM equipment options and measures. Choices may also be interdependent in the sense that the choices of some measures may affect the evaluation of others. This interdependence can be linked to budgetary or design issues; however, it can also stem from performance-based paths of code compliance which permit substitution of efficiency within and across end uses.

Program net impacts may differ from the gross impacts discussed above for several reasons:

- ***Free Ridership.*** Decision makers at participating sites might have installed measures *at a participating site* in the absence of the program. If so, they would be considered *free riders.*
- ***Participant Free Drivership.*** Decision makers may install non-incentivized measures at participating sites as a result of the program's influence. If so, they would be considered *participant free drivers*.
- ***Nonparticipant Free Drivership.*** Decision makers who install non-incentivized measures at nonparticipating sites as a result of the program's influence would be considered *nonparticipant free drivers*.
- ***Market Transformation.*** The existence of a program may cause long-term changes in the marketplace for DSM technologies. This may occur because of program-induced changes in awareness, changes in vendor stocking patterns, or reductions in technology costs. While this impact may be important for some programs (especially those dealing with new technologies), it is extremely difficult to quantify.

Evaluation literature reveals a wide range of approaches for estimating net program impacts. Three approaches were implemented for this evaluation:

- The use of self-reported free ridership,

- Comparisons of participant and nonparticipant efficiency levels, and
- Statistical modeling of efficiency choices.

These approaches are summarized below.

6.2 Self-Reported Estimates of Free Ridership

The most direct means of estimating free ridership and free drivership is to poll decision makers on the influence of the program on adoptions. This approach was taken as one option for addressing free ridership in the present study. A total of 122 decision makers representing 213 participating sites responded to the survey. Four surveys were not used due to incomplete data, leaving 209 surveys used in the analysis. They were polled on the likelihood that they would have installed measures *at a participating site* in the absence of the program. The specific question asked for each incented end use was:

> If SDG&E's incentive had not been available for the (measure) you installed, how likely is it that you would have installed lighting equipment more efficient than required to satisfy Title 24?

Responses were used to obtain free rider probabilities using the following assignments:

Definitely would have installed	1.00
Probably would have installed	0.67
Probably would not have installed	0.33
Definitely would not have installed	0.00
Don't know	missing

The probabilities were then weighted by total savings for the affected end use (as represented by the engineering estimates developed in the course of the project) and averaged. The results of this exercise are shown in Table 6-1. As indicated, the self-reported free rider ratios for lighting, cooling and motors/drives are very high and the implied net-to-gross ratios are correspondingly low. The free rider ratio for other end uses is equal to zero, but it covers relatively little savings. These results should be viewed skeptically. Self-reported estimates of free ridership and free drivership are subject to a variety of biases, including hypothetical bias and strategic bias (gamesmanship). The next two approaches focus on actual differences in efficiency at participating and nonparticipating sites.

Table 6-1: Self-Reported Free-Rider Ratios

Affected End Use	Self-Reported Free-Rider Ratio	Implied Net-to-Gross Ratio
Lighting	68.5%	31.5%
Cooling	63.6%	36.4%
Motors and Drives	67.0%	33.0%
Other End Uses	0.0%	100.0%

6.3 Comparisons of Efficiency Levels

An alternative means of estimating free ridership is to focus more directly on the relative efficiency levels chosen by participants and nonparticipants. This approach is recognized in the CPUC M&E Protocols as an option under the "Differences of Differences Approach." In the context of a new construction program like this one, the net-to-gross ratio is defined as:

$$\text{Net-to-Gross Ratio} = \frac{\text{Participant Savings} - \text{Nonparticipant Savings}}{\text{Participant Savings}}$$

where participant and non-participant savings are defined in turn as differences between baseline (Title 20/24) consumption and as-built consumption.

For the purposes of this section, realized savings per square foot are used for this purpose. Realized savings for participants are drawn from the last column of Table 5-2. Realized savings for nonparticipants are derived from the engineering estimates in Table 4-1, coupled with the realization rates in Table 5-2. Note that this approach takes account of free ridership and participant free drivership, but assumes that nonparticipant free drivership is zero. Table 6-2 presents a comparison of end-use savings per square foot for participants and nonparticipants, and indicates the implied net-to-gross ratios. The analysis is conducted on an end use basis. Note the following:

- ***Lighting savings*** are high for both participants and nonparticipants, leading to an implied net-to-gross ratio of only 53%. This is a function of the density-based Title 24 standard and is not surprising in new construction. For instance, participant lighting efficiencies tend to beat code even when no lighting incentives are paid to them. (Keep in mind that a participant is defined as a site that was incented for any end use. This approach is necessary because of the tradeoffs across end uses in code compliance. Also keep in mind that the efficiencies listed in Table 6-2 reflect all savings relative to code, not just savings for which incentives were paid.

- ***Space heating savings*** are negative. This is not because builders are installing substandard equipment, but rather because the installation of high-efficiency lighting increases heating requirements. Indeed, most of the negative heating savings simply represent the heating penalty on lighting efficiency. It should be kept in mind, of course, that the Title 24 base heating usage is very low relative to lighting, so these efficiencies are not directly comparable. Heating savings per square foot are only -0.060, whereas lighting savings per square foot are 2.81. Thus, the heating penalty is small relative to the lighting savings.
- ***Cooling savings*** are also reasonably high for both participants and nonparticipants, implying a net-to-gross ratio of only 58%. Since these values were based on actual and Title 20 equipment efficiencies, this suggests that nonparticipants are installing somewhat more efficient equipment than required by code. Again, though, it should be remembered that participant efficiency comes from not only incentivized but also non-incentivized equipment. Hence there is, in a sense, a common element of naturally occurring efficiency in both. Moreover, it should be recalled that a substantial share of cooling savings take the form of cooling bonuses from lighting savings.
- ***Ventilation savings*** is considerably higher for participants than for nonparticipants, indicating a net-to-gross ratio of 88%. This is traceable primarily to VAV systems and VSDs on VAV systems, measures that were relatively rare in nonparticipating buildings.
- ***Refrigeration savings*** is also far higher in participating sites than in nonparticipating buildings. Program data suggest that SDG&E may have been particularly active in promoting refrigeration measures. The refrigeration net-to-gross estimate based on this simple comparison is virtually equal to 100%.
- ***Process savings*** is much higher for participants than for nonparticipants. This is largely attributable to a few large process measures installed through the program. The associated net-to-gross ratio is over 89%.
- ***Combined savings*** for all end uses is more than twice as high for participants as for nonparticipants. This suggests an overall average net-to-gross ratio just over 59%.

Table 6-2: Comparisons of Realized End-Use Savings per Square Foot

End Use	Participant Savings	Nonparticipant Savings	Implied Net-to-Gross Ratio
Interior Lighting	2.816	1.319	0.532
Space Cooling	0.554	0.230	0.584
Space Heating	-0.060	-0.003	0.956
Ventilation	0.065	0.008	0.880
Refrigeration	0.303	0.002	0.995
Process	0.173	0.018	0.893
Whole Building	**3.851**	**1.574**	**0.591**

The values presented in Table 6-2 will be used for the purposes of this evaluation. As will be shown below, these estimated ratios yield very conservative estimates of net program savings.

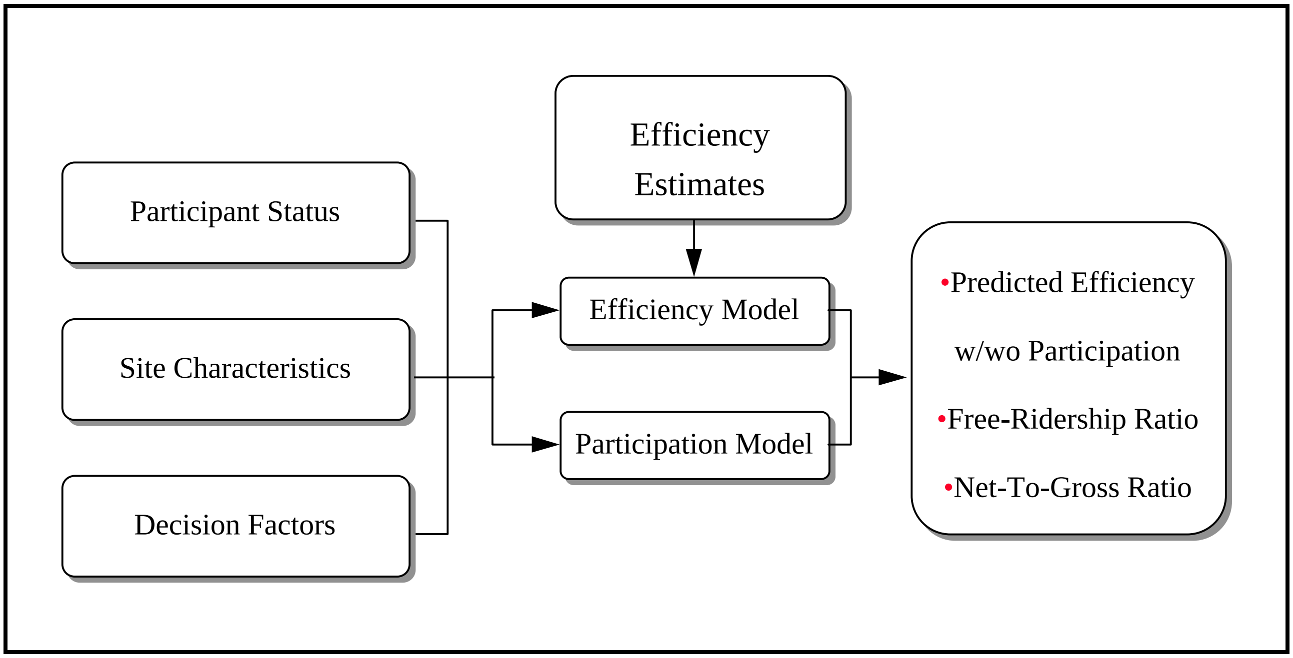
6.4 Efficiency Decision Modeling

While basing net-to-gross ratios on comparisons of savings satisfies the CPUC M&E Protocols, such comparisons of participants and nonparticipants may be affected by two kinds of bias. First, they ignore differences in site features that could influence efficiency levels. Second, they may suffer from self-selection bias. As explained in this section, it may be possible to mitigate these problems with a modeling approach. A statistical model can be used to characterize efficiency choices in terms of various levels of program participation and other determinants. The model can be designed to estimate the net impacts of participation on end-use specific efficiency levels, then used to develop a set of net-to-gross ratios reflecting both free-ridership and participant free-drivership effects. This efficiency model discussed below.

General Logic

The general logic of the model is illustrated in Figure 6-1. As shown, the model is designed to explain both participation decisions and efficiency decisions in terms of several drivers, including program participation, site characteristics, and decision factors. Once estimated, the model can be used to generate predictions of end-use efficiency levels for participants in the absence of the program. This prediction can be used to develop net-to-gross ratios and estimates of net program savings.

Figure 6-1: Efficiency Choice Model



Measures of Efficiency Choices

Much of the literature in program evaluation concentrates on the effects of utility programs on the adoption of discrete DSM measures. This approach is sensible for the analysis of programs with purely prescriptive offerings, like high-efficiency air conditioning or compact fluorescent programs. However, new construction programs cover multiple end uses and a variety of DSM equipment and measures that affect each use. Compliance with code and (in many cases) adherence to program requirements may be accomplished on a performance, rather than a prescriptive, basis. A builder can adopt a wide variety of measures and qualify for participation. To provide a reasonable assessment of program impacts on energy-efficiency decisions, comprehensive indicators of energy efficiency are needed. As in past studies, this issue was resolved by constructing an index of overall efficiency for each end use. Each efficiency index (EFF_{be}) is an estimate of proportional realized savings relative to the adjusted reference (baseline) consumption for an end use e and building b:

$$(1)\quad EFF_{be} = \hat{\alpha}_e(X_b)\hat{\beta}_e[EEBASE_{be} - EEACTUAL_{be}]/[\hat{\alpha}_e(X_b)EEBASE_{be}]$$

The numerator of this index represents realized savings, while the denominator reflects adjusted reference consumption.[12] In essence, the index for end use *e* and building *b* simply reflects the proportion by which the building's end-use load exceeds the applicable code. This means of quantifying savings acts to control for factors that affect both baseline usage and savings.

General Model Specification

The efficiency model takes on the following algebraic form:

$$(2) \quad PART_b = f_e(EFF_{be}, DECISION_b, SITE_b, \varepsilon_b)$$

$$(3) \quad EFF_{be} = g_e(PART_b, SITE_b, DECISION_b, \mu_b)$$

where $PART_b$ is a binary indicator of participation in the program, EFF_{be} is a the efficiency index for building *b* and end use *e*, $DECISION_b$ is a set of decision variables, and $SITE_b$ is a set of site characteristics. Note that this specific modeling approach, like simple comparisons of participants and nonparticipants, ignores nonparticipant free drivership.

Savings Through Design Efficiency Model

The specific model specified and estimated for this evaluation is designed to cover the following end uses: interior lighting, cooling, heating, ventilation, refrigeration and process. Together, these end uses comprise nearly all of the estimated realized savings from the program. The efficiency choice model is described below. First, the participation equation is given by:

$$(4) \quad PART_b = \frac{e^{gX_{bi}}}{1 + e^{gX_b}}$$

where:

$$(5) \quad \begin{aligned} gX_b &= g_0 + g_1 OWNOCC_b + g_2 SQFT_b + g_3 FCOST_b + g_4 SQFT_b \\ &+ g_5 NEW_b + g_6 EDUC_b + g_7 OFF_b + g_8 RES_b + g_9 GRO_b + g_{10} RET_b + g_{11} WAR_b \\ &+ g_{12} MED_b + g_{13} LOD_b + g_{14} PUB_b + g_{15} SRV_b + g_{16} MFG_b + h_b \end{aligned}$$

where the following definitions apply:

---

[12] This is a general formulation for the efficiency index. Insofar as the realization rate model chosen for this evaluation contains restrictions on the relative values of the coefficients on baseline usage and savings, the adjustment coefficients in this specification cancel out.

$PART_b$ = a binary variable indicating participation in the 1995 Savings Through Design Program
$OWNOCC_b$ = a binary variable indicating that the building was built for owner-occupancy
$SQFT_b$ = total surveyed site square footage
$FCOST_b$ = the reported importance of first cost as a determinant of construction design choices
$SQFT_b$ = square footage of the site in question
NEW_b = a binary indicator that the site is newly constructed (as opposed to a remodel or a tenant improvement
h_b = a random error term

and where the remainder of the regressors are binary variables representing the following building categories: offices (OFF_b), restaurants (RES_b), grocery stores (GRO_b), retail (RET_b), warehouses (WAR_b), medical (MED_b), education (EDU), lodging (LOD_b), public assembly (PUB_b), services (SRV_b) and manufacturing (MFG_b).

Efficiency models were estimated for three groups of end uses:

- ***Interior Lighting and Heating.*** These end uses were combined because virtually all of the (negative) space heating efficiency is associated with heating penalties of installed lighting measures.
- ***Cooling and Ventilation.*** These end uses were combined for simplicity and because it is fairly common for measures affecting both end uses to be installed at participating sites.
- ***Refrigeration and Process.*** Refrigeration and process end uses (water heating, air compressors, and motors) were combined to simplify the modeling task. Moreover, very few measures fall into the process category, and modeling these choices would be very difficult.

The lighting efficiency model is specified as follows:

$$(6)\quad \begin{aligned} EFFL_b = {} & a_0 + a_1 OWNOCC_b + a_2\left(EET24LT_b + EET24HT_b\right) + a_3 FCOST_b \\ & + a_4 NEW_b + a_5 EFFR_b + a_6 OTHPR_b + a_7 PART_b + m_b \end{aligned}$$

where:

$EFFL_b$ = the lighting efficiency ratio
$EFFR_b$ = the ranking of energy efficiency as a determinant of construction design

$OTHPR_b$	=	an indicator of the site's participation in one of SDG&E's other commercial programs
$EET24LT_b$	=	baseline lighting usage
$EET24HT_b$	=	baseline heating usage
μ_b	=	a random error term

Air conditioning and ventilation were combined into a single efficiency ratio for the purposes of the efficiency modeling. The associated efficiency model is given by:

$$(7)\quad \begin{aligned} EFFHVAC_b = s_0 + s_1 OWNOCC_b + s_2\left(EET24CL_b + EET24VT_b\right) + s_3 FCOST_b \\ + s_4 EFFR_b + s_5 CDDN_b + s_6 OTHPR_b + a_7 PART_b + j_b \end{aligned}$$

where:

$EFFHVAC_b$	=	an efficiency ratio for air conditioning and ventilation
$CDDN_b$	=	normal annual cooling degree days at the site
$EET24CL_b$	=	baseline cooling usage
$EET24VT_b$	=	baseline ventilation usage
φ_b	=	a random error term

Finally, the refrigeration/process efficiency model is represented as:

$$(8)\quad \begin{aligned} EFFR_b = w_0 + w_1 OWNOCC_b + w_2\left(EEBREF_b + EEBPR_b\right) + w_3 FCOST_b \\ + w_4 NEW_b + w_5 EFFR_b + w_6 OTHPR_b + w_9 PART_b + z_b \end{aligned}$$

where:

$EFFR_b$	=	the refrigeration/process efficiency ratio
$EEBREF_b$	=	baseline refrigeration usage
$EEBPR_b$	=	baseline process usage
x_b	=	a random error term.

Estimation of the Efficiency Models

The participation equation and a set of efficiency equations can be estimated using data on efficiency levels, participation, site features, and decision-maker characteristics. In the context of this specification, it is recognized that efficiency decisions and participation decision are simultaneously determined. In statistical jargon, both efficiency levels and participation are endogenous. Because of the endogeneity of program participation and self selection of the participants and nonparticipants, the estimation technique must be designed to resolve self-selection bias. There are three options in this regard:

- ***Mills Ratio Approach.*** First, a self-selection correction term (an inverse Mills Ratio) could be included in the efficiency equation. This method is typically attributed to Heckman.[13] The simple application of the inverse Mills Ratio is a subject of some controversy in the evaluation literature. However, a recent paper by Goldberg and Train[14] suggests that the ratio should be entered twice in the energy change equation: once as a free-standing term and once interactively with the participation term. The logic of this specification is that the Mills Ratio affects the change in usage as well as the impact of the participation variable in the energy change equation. With this specification, the net impact of participation on the change in energy consumption is a function of the Mills Ratio.
- ***Train Approaches.*** Train[15]proposes two alternative means of mitigating this form of bias. The first approach is actually attributable to Hartman (1988), and involves an instrumental variables procedure where predicted participation (call this *PART**) is substituted for the participation variable in the efficiency equation. The second is an alternative (yet very similar) approach in which the adoption model is estimated simultaneously with a participation model using nonlinear least squares with instruments.
- ***Wang Approach.*** Third, the adoption model and the participation model could be estimated simultaneously using full information maximum likelihood estimation. This approach can be attributed to Wang.[16] While it is more efficient than the two-stage least squares or instrumental variables approaches, it is also far more difficult to implement.

The literature on self selection has not yet yielded a clear consensus on the appropriate means of dealing with this problem in program evaluation. The controversy surrounding the proper means of treating self-selection bias will not be resolved in the course of this evaluation. Therefore, the net impact of program participation was estimated using two approaches: the Hartman instrumental variables approach and the Goldberg and Train double Mills Ratio method.

Lighting and Heating Model. The estimated Savings Through Design interior lighting and heating efficiency model is presented in Table 6-3. Two versions of the model are

---

13 Heckman, J. (1976). "The Common Structure of Statistical Models of Truncation Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models," Annals of Economic and Social Measurement, 5/4, 1976.

14 Goldberg and Train (1995). "Net Savings Estimation: An Analysis of Regression and Discrete Choice Approaches," Report submitted by XENERGY, Inc. to CADMAC Subcommittee on Base Efficiency, August 1995.

15 Train, K (1994b)."Estimation of Net Savings from Energy Conservation Programs," *Energy*, vol.19, No., 1994.

16 Wang, B (1994). "Maximum Likelihood Estimation with Sample Selection", Ph.D. Dissertation, Washington State University.

presented. Version 1 reflects the use of the Hartman instrumental variables approach, while Version 2 involves the use of the Goldberg and Train double Mills Ratio technique.

Version 1 of the lighting and heating model yields the following findings:

- The coefficient of the participation variable is 0.185, which indicates that participation increases combined lighting and heating efficiency by 0.185.
- Owner-occupancy has a significant positive effect on lighting and heating efficiency.
- The ranking of first cost as a factor in making energy efficiency decisions has a positive effect on efficiency (high ranks indicate less importance).
- If the site is new construction (rather than a remodel or a tenant improvement, efficiency tends to be lower).
- The better (lower) the ranking of efficiency as a factor in making construction decisions, the higher the efficiency level.
- Efficiency levels tend to be lower in buildings with high Title 24 lighting allowances.
- The variable representing participation in other programs entered the equation with the wrong sign and was subsequently dropped.

Version 2 of the lighting and heating efficiency equation confirms most of the findings from Version 1. The participation variable is significant, but both Mills Ratio terms are not. The combination of the two participation terms yields a net efficiency impact of 0.18258. This is virtually identical to the result derived from Version 1.

Table 6-3: Estimated Lighting and Heating Efficiency Model (t values in parentheses)

Explanatory Variable	Version 1	Version 2
Intercept	0.15649 (3.05)	0.18191 (2.93)
$PART_b$	-	0.20205 (3.58)
$PART^*_b$	0.18492 (4.18)	-
MR_b	-	0.01492 (0.59)
$PART_b\ MR_b$	-	0.04615 (1.37)
$OWNOCC_b$	0.04693 (2.14)	0.03659 (1.70)
$FCOST_b$	0.02998 (3.83)	0.02812 (3.64)
NEW_b	-0.06418 (3.30)	-0.08629 (4.38)
$EFFR_b$	-0.01927 (2.25)	-0.02354 (2.83)
$EET24LT_b + EET24HT_b$	-0.00439 (2.13)	-0.00405 (2.01)
Adjusted R^2	0.160	0.204

Cooling and Ventilation Model. The estimated cooling and ventilation efficiency model is presented in Table 6-4. Again, two versions of the model are presented. Version 1 yields the following findings:

- The estimated coefficient on the predicted participation variable is insignificant. Its point estimate suggests that participation increases combined cooling and ventilation efficiency by only 0.033.
- Neither owner-occupancy nor the ranking of first cost as a factor in making energy efficiency decisions has a significant effect on cooling and ventilation efficiency.
- The better (lower) the ranking of efficiency as a factor in making construction decisions, the higher the efficiency level.
- Efficiency levels tend to be lower in buildings with high baseline cooling loads.
- The variable representing participation in other programs took on the wrong sign, and was ultimately dropped from the model.

Again, Version 2 confirms the general findings of Version 1. However, the estimated net impact of participation on cooling and ventilation efficiency is very different from the result of Version 1. The solution of the equation yields an estimated net impact of 0.08588, which is more than twice as high as the estimate derived from Version 1..

Table 6-4: Estimated Cooling and Ventilation Efficiency Model

Explanatory Variable	Version 1	Version 2
Intercept	0.09941 (1.94)	0.04314 (0.97)
$PART_b$	-	0.07452 (1.81)
$PROB_b$	0.03317 (1.30)	-
MR_b	-	0.02498 (1.18)
$PART_b\ MR_b$	-	-0.02558 (1.04)
$OWNOCC_b$	0.00508 (0.43)	0.00372 (0.32)
$FCOST_b$	0.00110 (0.20)	0.00167 (0.30)
$EFFR_b$	-0.01068 (1.84)	-0.01073 (1.92)
$CDDN_b$	-0.00002 (0.38)	-
$EET24CL_b + EET24VT_b$	-0.00020 (1.96)	-0.00016 (1.56)
Adjusted R^2	0.015	0.022

Refrigeration and Process Model. The estimated refrigeration and process efficiency model is presented in Table 6-5. Version 1 suggests the following:

- Predicted participation has a highly significant impact on net efficiency. The coefficient suggests that this impact is 0.18492. However, the gross efficiency of participants covered by this analysis is only 0.10556.
- Owner-occupancy has a positive effect on efficiency.
- Oddly, the rankings of energy efficiency (where low means more important) has a positive effect on the choice of efficiency. This is presumably an anomalous result.
- The size of baseline refrigeration and process loads has a strong positive impact on efficiency.

Version 2 yields almost identical results. The solution of the equation reveals a net impact of 0.16012.

Table 6-5: Estimated Refrigeration and Process Efficiency Model

Explanatory Variable	Version 1	Version 2
Intercept	-0.13521 (6.04)	-0.12655 (4.07)
$PART_b$	-	0.14740 (4.97)
$PROB_b$	0.15773 (7.06)	
MR_b	-	0.02003 (1.45)
$PART_b\ MR_b$	-	-0.02385 (1.29)
$OWNOCC_b$	0.04294 (3.34)	0.00959 (0.79)
$FCOST_b$	-0.00577 (1.25)	-0.01200 (2.62)
$EFFR_b$	0.01488 (2.64)	0.01790 (3.27)
$EEBREF_b + EEBPR_b$	0.00142 (14.51)	0.00136 (13.55)
Adjusted R^2	0.474	0.522

Use of the Model to Infer Net-to-Gross Ratios

Once the efficiency equation is estimated, it can be used to develop a set of estimates of net-to-gross ratios as:

$$(10)\quad Net\text{-}to\text{-}Gross\ Ratio_{be} = (\partial EFF_{be} / \partial PART_b) / EFF_{be}$$

In the language of the CPUC M&E Protocols, the derivative of efficiency with respect to the participation variable is essentially a difference of differences calculation of net program impacts. That is, it represents the difference between participant and nonparticipant efficiency, *controlling for other factors in the equation*. Division of this estimated net impact by the gross efficiency level of participants thus yields a net-to-gross ratio consistent with the Protocols.

Net-to-gross ratios were developed for all participants and aggregated to the program level through the development of weighted averages of these ratios across sites. Note that the net impact on efficiency (the numerator of the net-to-gross ratio) is computed slightly differently in the two versions. In Version 1 of the lighting model, for instance, this derivative is given by:

$$(11)\ \P EFFL_b \,/\, \P PART_b = \P EFFL_b \,/\, \P PROB_b = \hat{a}_7$$

where $\hat{a}_8$ is the estimated coefficient of the predicted participation variable; whereas in Version 2, it is derived as:

$$(12)\ \P EFF_b \,/\, \P PART_b = \hat{a}_7 + \hat{a}_8 MR_b$$

where $\hat{a}_7$ is the estimated coefficient of the participation variable and $\hat{a}_8$ is the estimated coefficient of the interaction term involving the Mills Ratio and the participation variable.

The results of this exercise are shown in Table 6-6. Note that, since the efficiency equations are estimated with data on sites with completed decision-maker surveys, the net -to-gross ratios are also estimated with only these sites. Given the excellent coverage of the decision-maker survey, however, these ratios should represent the total participant population reasonably well. The findings are mixed, as described below:

- As shown in Table 6-6, the net-to-gross ratios estimated for lighting and heating are virtually identical across equations. They suggest that two-thirds of the gross savings experienced by participants can be attributed to participation.
- The results for cooling and ventilation, however, are not robust across specifications. This is due to the substantial variation in cooling and ventilation efficiencies within the participant and nonparticipant samples. The estimate derived from the Hartman approach appears too low in light of the simple comparisons of savings discussed earlier, while the estimate derived from the Goldberg and Train approach seems implausibly high.
- The net-to-gross ratios derived for refrigeration and process end uses exceed 1.0, and are thus not reasonable per se. This may be attributable to the linearity of the efficiency model. However, the model results do generally fit with other evidence in suggesting that the net-to-gross ratio for refrigeration and process end uses is very high.

Table 6-6: Model-Based Estimated Net-to-Gross Ratios

End Use	Hartman Approach			Goldberg/Train Approach		
	Net Impact	Gross Impact	Net-to-Gross Ratio	Net Impact	Gross Impact	Net-to-Gross Ratio
Interior Lighting and Heating	0.1849	0.2765	0.6687	0.1826	0.2765	0.6604
Cooling and Ventilation	0.0332	0.0888	0.3739	0.0859	0.0888	0.9673
Refrigeration and Process	0.1577	0.1056	1.4934	0.1601	0.1056	1.5161

6.5 Estimated Net Program Savings

Table 6-7 summarizes various estimates of savings yielded by the analysis. The net-to-gross ratios used for this calculation are based on the simple difference-of-differences approach discussed in Section 6.3. As indicated by the efficiency modeling results shown in Section 6.4, the ratios used here probably yield very conservative estimates of net program savings.

As shown in Table 6-7, estimated net energy savings amount to just over 28 GWh. The net demand impact is 4.98 MW.

Table 6-7: Estimated Net Realized Program Energy Savings

End Use	Gross Realized Savings	Net-to-Gross Ratio	Estimate of Net Realized Savings
Total Savings (GWh)			
Lighting	34.869	0.532	18.550
Cooling	6.862	0.584	4.007
Heating	-0.748	0.956	-0.715
Ventilation	0.811	0.880	0.714
Refrigeration	3.744	0.995	3.725
Process	2.148	0.893	1.918
Total Whole Building	**47.686**	**0.591**	**28.200**
Savings per Square Foot (kWh)			
Lighting	2.816	0.532	1.498
Cooling	0.554	0.584	0.324
Heating	-0.060	0.956	-0.057
Ventilation	0.065	0.880	0.057
Refrigeration	0.303	0.995	0.301
Other	0.173	0.893	0.154
Total Whole Building	**3.851**	**0.591**	**2.277**
Savings per Participant (kWh)			
Lighting	122,347	0.532	65,089
Cooling	24,075	0.584	14,060
Heating	-2,625	0.956	-2,510
Ventilation	2,847	0.880	2,505
Refrigeration	13,137	0.995	13,071
Other	7,539	0.893	6,732
Total Whole Building	**167,321**	**0.591**	**98,948**

Table 6-8: Estimated Net Program Demand Savings

End Use	Gross Realized Savings	Net-to-Gross Ratio	Estimate of Net Realized Savings
Total Savings (MW)			
Lighting	5.928	0.532	3.154
Cooling	1.578	0.584	0.922
Heating	0.000	0.956	0.000
Ventilation	0.122	0.880	0.107
Refrigeration	0.412	0.995	0.410
Other	0.430	0.893	0.384
Total Whole Building	**8.469**	**0.588**	**4.977**
Savings per Square Foot (kW)			
Lighting	0.479	0.532	0.255
Cooling	0.127	0.584	0.074
Heating	0.000	0.956	0.000
Ventilation	0.010	0.880	0.009
Refrigeration	0.033	0.995	0.033
Other	0.035	0.893	0.031
Total Whole Building	**0.684**	**0.588**	**0.402**
Savings per Participant (kW)			
Lighting	20.799	0.532	11.065
Cooling	5.537	0.584	3.234
Heating	0.000	0.956	0.000
Ventilation	0.427	0.880	0.376
Refrigeration	1.445	0.995	1.438
Other	1.508	0.893	1.347
Total Whole Building	**29.716**	**0.588**	**17.459**

The CPUC M&E Protocols require confidence intervals for both net and gross savings. Of course, building confidence intervals for net savings would require standard errors of net savings. Given the many calculations that enter into the estimation of net savings, however, true standard errors would be virtually impossible to obtain. Approximate net savings confidence intervals were derived as follows:

- *Relative* confidence intervals (intervals cast in terms of percentages of the point estimate) were developed for the estimates of net efficiency impacts flowing from the efficiency models presented in Section 6.4. These intervals are presented in Table 6-9.
- These relative confidence intervals were then weighted by estimated end use savings to obtain a whole-building relative interval.
- Finally, the relative interval was applied to the various measures of net savings. .

The results of this approach are presented in Table 6-10.

Table 6-9: Relative Confidence Intervals by End Use Group

End Use Group	90% Confidence Interval	80% Confidence Interval
Lighting and Space Heating	0.606 to 1.394	0.694 to 1.306
Air Conditioning and Ventilation	-0.265 to 2.265	-0.015 to 1.985
Refrigeration and Process	0.767 to1.233	0.830 to 1.170
Whole Building	**0.492 to 1.508**	**0.603 to 1.392**

Table 6-10: Confidence Intervals for Estimated Net Realized Savings

Measure of Savings	Point Estimate	90% Confidence Interval	80% Confidence Interval
Net Energy Savings			
Total Program (GWh)	28.200	13.874 to 42.526	17.005 to 39.254
per Square Foot (kWh/ft^2)	2.277	1.120 to 3.434	1.373 to 3.170
per Building (kWh)	98,948	48,682 to 149,214	59,666 to 137,736
Net Demand Savings			
Total Program (MW)	4.977	2.449 to 7.505	3.001 to 6.928
per Square Foot (W/ft^2)	0.402	0.198 to 0.606	0.242 to 0.560
per Building (kW)	17.459	8.590 to 26.328	10.528 to 24.303

Appendix A

On-Site Survey Instrument

Site ID Number

1996 Commercial On-Site Survey

for

SDG&E NEW CONSTRUCTION EVALUATION

7/5/96

Site/Survey Information:

Business Name: __

Street Address: __

City, State: __ , __ __

Zip Code: __ __ __ __ __ - __ __ __ __

Contact Name: __

Contact Title: __

Contact Phone #: (_ _ _) _ _ _ - _ _ _ _ ext. _ _ _ _ _

Survey Tracking Information:

	Date:	Initials
Field Survey:	__ __ / __ __ / __ __	__ __ __
Quality Control Check:	__ __ / __ __ / __ __	__ __ __
Data Entry:	__ __ / __ __ / __ __	__ __ __
Survey Received by RER:	__ __ / __ __ / __ __	
Data Received by RER:	__ __ / __ __ / __ __	
SITEPRO Processing:	__ __ / __ __ / __ __	

Site Connected Load Check Sheet

End-Use Description	Connected kW	Loads kBtu/h
Swimming Pool/Spa	________	________
Packaged HVAC		
Indoor Fans	________	
Cooling Units	________	________
Heating Units	________	________
Built-up HVAC		
Supply Fans	________	
Return Fans	________	
Cooling Units	________	________
Heating Units	________	________
Heat Rejection	________	
Pumps	________	
Exhaust Fans	________	
Water Heating	________	________
Outdoor Lighting	________	
Indoor Lighting	________	
Standard Office Equipment	________	
Non-Standard Office Equip.	________	
Miscellaneous Equipment	________	________
Food Service Equipment	________	________
Refrigeration		
Refrigerators/Freezers	________	
Self-Contained Commercial	________	
Remote	________	
Motors/Engines	________	________
Air Compressor	________	
Process Equipment	________	________
Water/Steam Boilers	________	________
TOTALS		
Billed Demand		

Electric Accounts & Meters

Item #	Account Number:	Meter Numbers :	Part of sample Yes No	Add Delete to survey
1	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
2	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
3	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
4	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
5	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
6	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
7	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
8	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
9	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
10	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D

Do electric account numbers match sample account selection for this site? If "No" or "Not Verified", then explain discrepancy in comments section below.	☐Yes ☐No ☐Not Verified

Gas Accounts & Meters

Item #	Account Number:	Meter Numbers :	Part of sample Yes No	Add Delete to survey
1	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
2	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
3	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
4	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
5	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
6	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
7	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
8	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
9	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D
10	__ __ __ __ __ __ __ __ __ __ __	__ __ __ __ __ __ __ __ __ __	Y N	A D

Do gas account numbers match sample account selection for this site? If "No" or "Not Verified", then explain discrepancy in comments section below.	☐Yes ☐No ☐Not Verified

Comments ____

Site Activity Information

Describe the primary *activity* of this site: ______________________________
____
____

What are the *products/services* of this site: ______________________________
____
____

Site Activity Code: _ _ _ *(Use activity codes from table below)*

Site Activity Codes

Office:		**Warehouse:**		**Public Assembly:**	
Administration and management	011	Refrigerated Warehouse	051	Church	091
Financial / Legal	012	Non-refrigerated Warehouse	052	Recreational or Other	092
Insurance/Real Estate	013	**Health Care:**		**Services:**	
Other Office	014	Hospital	061	Gas Station / Auto Repair	101
Restaurant:		Nursing Home	062	Repair (Non-Auto)	102
Fast Food or Self Service	021	Medical Office	063	Other Service Shop	103
Table Service	022	Clinic/Outpatient Care	064	**Manufacturing:**	
Bar/Tavern/Nightclub/Other	023	**Education:**		Assembly / Light Mfg.	111
Food Store:		Daycare or Preschool	071	Med/Heavy Equip. Mfg.	112
Supermarket	031	Elementary / Secondary School	072	Food/Beverage Processor	113
Convenience Store	032	College or University	073	Mining	114
Other Food Store	033	Vocational or Trade School	074	**Misc:**	
Retail Store:		**Lodging:**		Construction	121
Department / Variety Store	041	Hotel	081	Agriculture	122
Shop in Enclosed Mall	042	Motel	082	Apartments	123
Other Retail Store	043	Resort	083	**Other:** Describe: __________	130

____
____
____

General Information

How many part-time employees? __________

How many full-time employees? __________

Is this space owner-occupied or leased? **O L**

What year was this business established? __________

What is the total floor area for this business? __________

How many buildings are part of this business? __________

What year was the majority of the facility built? __________

New Construction, Remodel, or Tenant Improvement (TI)

How many square feet of floor space were added? __________

How many square feet of floor space were remodeled? __________

How many square feet of floor space were affected by TIs? __________

Was the space built to suit? **Y N**

Sketch the floor plan of all the buildings at the Survey Site and identify the *Survey Area* and the *Shared Service Area*. Indicate on the drawing the boundaries of different space usage areas. Include building dimensions and mark the orientation.

Surveyed area is:

❒ Single Building

❒ Multiple Buildings - How many: ________

❒ Part of a Building - What percent of the total building square footage: _________

- How many other tenants in building? _________

Metering arrangement model number ____ , if no match was found enter N and show meters on above picture.

Describe area included in the survey: ______________________________

Shared Utility Services:

❒ **Survey area is receiving heating and/or cooling from a central system.**
When survey area is receiving heating or cooling from a central system which is not part of survey area complete this section. ("not part of survey area" means - the heating/cooling equipment [boilers and chillers] are connected to a different utility service [account & meter] than survey area).

Shared Central Equipment:	**Unit #1**	**Unit #2**	**Unit #3**
Equipment Fuel Type: **E** = Electricity$_1$ **N** = Natural Gas$_2$ **F** = Fuel Oil$_3$ **L** = LPG$_4$			
Account Item number from page 3			
Equipment Type: **C** = Chiller$_1$ **B** = Boiler$_2$ **O** = Other$_3$			
Total Capacity			
Units for Capacity **T** = Tons$_1$ **kB** = kBtuh$_2$	T kB	T kB	T kB
Percent of total capacity utilized by survey area			

❒ **Survey area is sharing a meter with another business or building.**
When survey area is sharing a meter with another building or business complete the table below. This information is used to calculate energy usage of each shared meter by the survey area.

Shared Meter Information:

#	Account Item #	Activity Code	Floor Area (Sq. Ft.)	Percent used by survey area	Comment
1					
2					
3					
4					
5					

❒ **Survey area is a large campus or Industrial park with multiple buildings.**
Perform survey on selected building(s) and complete table below for remaining buildings.

Multiple Building Sites - Building Inventory

Item #	Activity Code	Floor Area Total Sq. Ft	**Heating** % of total Sq. Ft.	Fuel Type	Equip. Type **U**nitary / **C**entral	**Cooling** % of total Sq. Ft.	Fuel Type	Equip. Type **U**nitary / **C**entral
1					U C			U C
2					U C			U C
3					U C			U C
4					U C			U C
5					U C			U C
6					U C			U C
7					U C			U C
8					U C			U C
9					U C			U C
10					U C			U C
11					U C			U C
12					U C			U C
13					U C			U C
14					U C			U C
15					U C			U C
16					U C			U C
17					U C			U C
18					U C			U C
19					U C			U C
20					U C			U C
21					U C			U C
22					U C			U C
23					U C			U C
24					U C			U C
25					U C			U C
26					U C			U C
27					U C			U C
28					U C			U C
29					U C			U C
30					U C			U C

Energy Efficiency Improvement Measure

Please identify if the following efficiency improvement measures have been implemented at the site and the year that the implementation was performed.	**"X" if measure installed**	**Year Installed**
Lighting:		
T-8 or equivalent fluorescent lamps	___	__ __
Electronic ballasts	___	__ __
Hybrid ballasts	___	__ __
Delamping	___	__ __
Optical reflectors	___	__ __
Occupancy Sensors	___	__ __
Timeclocks	___	__ __
Daylighting controls	___	__ __
LED Exit Signs	___	__ __
HVAC:		
Economizer	___	__ __
Evaporative pre-cooler	___	__ __
Dehumidifier	___	__ __
Energy management systems	___	__ __
High efficiency HVAC Equipment	___	__ __
VSD/ASD chiller	___	__ __
VSD/ASD pumps	___	__ __
VSD/ASD fans	___	__ __
Conversion to Variable Air Volume system	___	__ __
Conversion to Constant Volume system	___	__ __
Building Envelope:		
Window tint or film	___	__ __
Above-code roof insulation	___	__ __
Above-code wall insulation	___	__ __
Miscellaneous:		
Improvements to water heating system	___	__ __
Improvements to refrigeration system	___	__ __
High efficiency motors (non-HVAC)	___	__ __
CO sensors	___	__ __

Other/Comments:

Hot Water Use			
Commercial food service:	Number of meals served per day:	Breakfast	
		Lunch	
		Dinner	
	Number of seats in the food service area:		
	Disposable Dishes? (circle response)		Y N
	Number of loads of dishes washed per day?		
Number of lavatories with hot water: (exclude Hotels, Hospitals and Restaurants)			
Pounds of laundry washed per day? (lb)			
Other domestic hot water uses? (Gal/Day)			
Lodging:	Number of usable rooms in Hotels/Motels		
	Average # of rooms occupied		
	Number of Apartments		
Office:	Average % of occupied (Non-vacant) space in office buildings		
Hospital:	Number of beds in hospital		
	Average % of beds occupied in hospital		
School:	Average number of enrolled students in schools		

On-Site Power Generation	#1	#2
Plant Type: **I** = Internal Combustion Engine$_1$ **G** = Gas Turbine$_2$		
What is the plant capacity? (kW)		
Fuel Type: **E** = Electricity$_1$ **N** = Natural Gas$_2$ **F** = Fuel Oil$_3$ **O** = Other$_4$ __________		
Use for generated power: **P** = Peak Shaving$_1$ **B** = Base load$_2$ **O** = Other$_3$___________		
What percent of generated electricity is sold back to the utility?	%	%
Average operating hours per day		
Number of operating days per year		

Thermal Storage	#1	#2
Storage type **C** = Chilled Water$_1$ **I** = Ice$_2$ **O** = Other$_3$ ______________		
Thermal storage capacity (Ton-Hour)		
Storage is charged: from . . . . . . Use 24 hour (military time) to designate		
to . . . . time period. (eg., 1 pm would be 13)		
Storage is discharged: from		
to		
Storage provides what % of hottest day peak cooling load		

Swimming Pool/Spa	# 1	# 2	# 3
Type: **S** = Swimming Pool$_1$ **H** = Hot Tub$_2$ **O** = Other$_3$			
What is the size of the pool (sq. ft.)?			
Heater Capacity (kBtu/hr or kW)			
Fuel Type: **NO** = Not Heated$_0$ **E** = Electricity$_1$ **N** = Natural Gas$_2$ **L** = LPG$_4$ **S** = Solar$_5$			
Pump Size (hp)			
Age of the heating equipment?			
Location (Outdoors = 99)			

Operation, Occupancy and HVAC

Operation Schedule (define a typical week)

Day Types *(up to 3 types)*	**Applicable Days**	**Business Hours**	**Maximum Occupancy**
Standard Day	M T W T F S S H	from __ __ to __ __	_ _ _
Non-Standard Day	M T W T F S S H	from __ __ to __ __	_ _ _
Closed	M T W T F S S H		

Seasonal Operation

Do the operating hours change by season?	Yes No
If yes, list the beginning and ending months (1-12) of the secondary schedule and complete secondary schedules in Appendix, page 32.	Begin _ _ through End _ _

*Note: Secondary schedules are used if there is seasonal variation in operation.

Occupancy Schedule

Day Type	Start Hour	% of Max Occup	Stop/ Start Hour	% of Max Occup	Stop/ Start Hour	% of Max Occup	Stop/ Start Hour	% of Max Occup	Stop/ Start Hour	% of Max Occup
Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Cooling Temperature Schedule

Day Type	Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F
Std	00									
Non-Std	00									
Closed	00									

Heating Temperature Schedule

Day Type	Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F
Std	00									
Non-Std	00									
Closed	00									

Equipment Schedules

Day Type	Start Hour	% of Equip On	Stop/ Start Hour	% of Equip On	Stop/ Start Hour	% of Equip On	Stop/ Start Hour	% of Equip On	Stop/ Start Hour	% of Equip On
Indoor Lighting Schedule										
Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%
Outdoor Lighting Schedule										
Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%
Office Equipment										
Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%
Miscellaneous Equipment Schedule										
Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%
Cooking Schedule										
Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%
Process Equipment Schedule										
Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Site Information

Number of Floors	Total Enclosed Floor Area, ft^2	Total Roof Area, ft^2	Ground Floor Area, ft^2

Site Use Assignments (Identify maximum of six areas)

Item #	Area ID#	Site Use Type/Description	% of Total Site Floor Area	% Cooled	% Heated	New Const?
1		Apartments				Y N
2		Classroom				Y N
3		Clean Room				Y N
4		Common Areas				Y N
5		Conference Rooms				Y N
6		Cooking				Y N
7		Dining				Y N
8		Health Facility				Y N
9		Examination Room				Y N
10		Patient Room				Y N
11		Laundry Rooms				Y N
12		Loading Dock				Y N
13		Lobby/Reception Area				Y N
14		Lodging				Y N
15		Manufacturing				Y N
16		Mechanical/Electrical Room				Y N
17		Office				Y N
18		Office Common Areas				Y N
19		Office Conference Rooms				Y N
20		Operating Room, Critical Care				Y N
21		Parking Structure (enclosed not open lot)				Y N
22		Patio Area				Y N
23		Pool/Spa Area				Y N
24		Public Assembly				Y N
25		Gymnasium				Y N
26		Library				Y N
27		Retail				Y N
28		Stairs/Hallways				Y N
29		Vacant				Y N
30		Warehouse/Storage (Non-Refrigerated)				Y N
31		Warehouse Refrigerated				Y N
32		Other #1: (describe)				Y N
33		Other #2: (describe)				Y N
34		Other #3: (describe)				Y N
35		Other #4: (describe)				Y N
		Total	**100%**	--	--	--

Building Specifications

Exterior Wall Types:		W1	W2
Wall construction type	From Wall Type table		
Insulation material type			
Insulation R-value			
Insulation location	**C** = In cavity$_1$ **E** = Exterior$_2$ **I** = Interior$_3$		
Wall Color	**D** = Dark$_1$ **M** = Medium$_2$ **L** = Light$_3$		

Interior Wall Types:		I1	I2
Wall construction type	From Wall Type table		
Insulation material type			
Insulation R-value			

Wall Types		Wall Types (Cont.)		Insulation Types		(R/in)
WFF	2 X 4 Wood Frame Wall$_1$	WC8	8" Solid Concrete Wall$_8$	BAT	Batt or Blanket$_1$	3.3
WFM	2 X 4 Metal Frame Wall$_2$	WC10	10" Solid Concrete Wall$_9$	LSF	Loose fill$_2$	2.7
WSF	2 X 6 Wood Frame Wall$_3$	WC12	12" Solid Concrete Wall$_{10}$	XPE	Expanded perlite$_3$	2.8
WSM	2 X 6 Metal Frame Wall$_4$	WBLO	Concrete Block Wall$_{11}$	XPS	Expanded polystyrene$_4$	3.8-5.0
WAIR	Air Wall$_5$	WBRI	Brick Wall$_{12}$	RDG	Rigid board$_5$	2.8-4.0
WC4	4" Solid Concrete Wall$_6$	WGLS	Glass Curtain Wall$_{13}$	OTH1	Other1$_6$ ___________	_____
WC6	6" Solid Concrete Wall$_7$	WADB	Adiabatic$_{14}$	OTH2	Other2$_7$ ___________	_____

Roof/Ceiling Types:		R1
Roof construction type	RFAT = Framed With Attic$_1$ RMET = Metal Decking$_2$ RFNO = Framed Without Attic$_3$ RCON = Concrete Decking$_4$ RADB = Adiabatic$_5$	
Roof Surface	**B** = Built-up$_1$ **W** = Wood Shingle$_2$ **M** = Metal$_3$ **C** = Clay/Cement Tile$_4$ **A** = Asphalt Roll/shingle$_5$	
Roof Finish	**R** = Reflective$_1$ **F** = Flat$_2$	
Roof Color	**D** = Dark$_1$ **M** = Medium$_2$ **L** = Light$_3$	
Roof Insulation type		
Roof Insulation R-value		
Suspended Ceiling?		**Y** **N**
Ceiling Insulation type		
Ceiling Insulation R-value		

Floor Types:		F1
Floor construction type	**S** = Slab$_1$ **C** = Crawl$_2$ **U** = Unheated Basement$_3$ **O** = Open (Garage)$_4$ **A** = Adiabatic$_5$	
Insulation material type		
Insulation R-value		

Comments ____

____

____

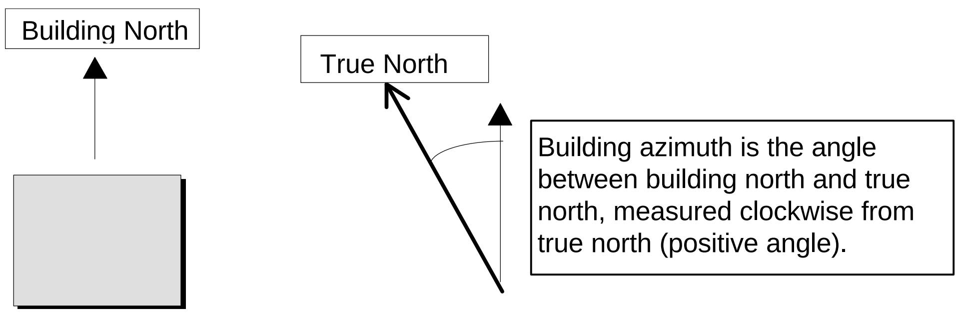
____

Building Specifications (Cont'd)

Shading Parameters for Overhangs and Side Fins

Glazing Types:		G1	G2	G3
Layers of glazing				
Type of Glazing	**C** = Clear$_1$ **T** = Tinted$_2$ **R** = Reflective$_3$ **O** = Opaque$_4$ **L** = Low E$_5$ **I** = Infrared Reflective$_6$ **G** = Gas Filled$_7$			
Window frame type	**M** = Metal$_1$ **W** = Wood$_2$ **O** = Other$_3$ ___________			
Overhang, ft				
Side Fin, ft				
Interior Shading	**F** = Fixed interior$_1$ **M** = Moveable interior$_2$ **N** = None$_3$			
Window Height, ft				
Window Width, ft				

Wall Assignments and Building Orientation:



Enter building azimuth: _______

External Wall Construction				
Orientation	**N**	**E**	**S**	**W**
Total Wall Area, ft²				
Exterior Wall Type W1 %				
Exterior Wall Type W2 %				
Sum of Exterior Walls	100%	100%	100%	100%
Window G1 %				
Window G2 %				
Window G3 %				
Door D1 - metal insulated				
Door D2 - metal, no insulation				
Door D3 - wood				
Door D4 - glass				

Area/Wall Assignments				
Area ID #	**% of Total N Wall Area**	**% of Total E Wall Area**	**% of Total S Wall Area**	**% of Total W Wall Area**

(Note: '%' refers to the percent of Total Wall Area)

Packaged Units (Use letters A, B, etc.)	Ltr __	Ltr __	Ltr __	Ltr __
Distribution System:				
Air Distribution system type: **PSZ** = Packaged Single Zone1 **PMZ** = Packaged Multi Zone2 **PUV** = Unit Ventilator3 **PTAC** = Packaged Terminal Air Conditioner4 **PVAV** = Packaged Variable Air Volume5				
On/Off Control: **M** = Manual (On/Off)1 **A** = Always On2 **N** = Night Setback3 **W** = Weekly Clock4 **E** = EMS5 **P** = Programmable Thermostat6				
Thermostat Type: **P** = Pneumatic1 **E** = Electric /electronic2 **D** = Direct digital controls3				
Optimum Start (Y/N)	**Y N**	**Y N**	**Y N**	**Y N**
Estimated year of installation				
Equipment Manufacturer				
Model Number				
Indoor fan (hp/unit)				
Supply air rate (CFM)				
% Outside air				
Economizer Yes or No?	**Y N**	**Y N**	**Y N**	**Y N**
Return air rate (CFM)				
Return fan motor (HP)				
Cooling Equipment:				
Type: **NO** = None1 **DX** = Direct Expansion2 **EC** = Evaporative Cooler3 **CH** = Chilled Water4				
Number of Units				
Compressor: Volts				
Amps				
Phase				
kW = (V × A × √ Phase × 0.85)/1000				
Capacity Output ((kBTU/hr)/unit)				
Efficiency: **EER (or % EC for Evap. Cool.)**				
or **SEER**				
VSD Compressor? (Y / N)	**Y N**	**Y N**	**Y N**	**Y N**
Heating Equipment:				
Type: **FN** = Furnace1 **EH** = Electrical2 **HP** = Heat Pump3 **PUH** = Unit Heater4 **NO** = None5 **BB** = Built-up Boiler6 **OT** = Other7_______________				
Fuel: **E** = Electricity1 **N** = Natural Gas2 **F** = Fuel Oil3 **L** = LPG4 **W** = Wood5 **S** = Solar6				
Number of Units				
Electrical Input (kW)				
Capacity Output (kBTU/hr)				
Efficiency: % (or for HP enter COP)				
or HSPF (for HP)				
HP only: Supplemental Heating Capacity (kW)				
Serves Area ID # Enter Area ID number or A for all areas				

Built-up HVAC (Use numbers)	# __	# __	# __	# __
Distribution Systems				
System Type: **OT** = Other$_0$ ________ **FP** = Four-Pipe Fan Coil$_1$ **SZ** = Single Zone$_2$ **VA** = Variable Air Volume$_3$ **MZ** = Multi Zone$_4$ **CV** = Constant Volume Reheat$_5$ **DD** = Dual Duct$_6$ **WL** = Water Loop Heat Pump$_7$ **TP** = Two-Pipe Fan Coil$_8$				
On/Off Controls: **M** = Manual (On/Off)$_1$ **A** = Always On$_2$ **N** = Night Setback$_3$ **W** = Weekly Clock$_4$ **E** = EMS$_5$				
Thermostat Type: **P** = Pneumatic$_1$ **E** = Electric/electronic$_2$ **D** = Direct digital controls$_3$				
Supply Air Temperature Control: **C** = Constant$_1$ **O** = Reset OAT$_2$ **D** = Reset Demand$_3$				
Supply air temperature cooling setpoint (°F)				
Supply air temperature heating setpoint (°F)				
Supply fan power (hp/unit)				
Quantity of supply fans				
Supply fan type and control: **IA** = inlet guide vanes, air foil fan$_1$ **IF** = inlet guide vanes, forward curved fan$_2$ **DF** = discharge damper, FC fan$_3$ **VA** = vane axial fan w/ variable pitch$_4$ **VS** = variable speed drive$_5$				
Supply air rate (CFM/unit)				
% Outside Air				
Return fan power (hp/unit)				
Quantity of return fans				
Return fan type and control: **IA** = inlet guide vanes, air foil fan$_1$ **IF** = inlet guide vanes, forward curved fan$_2$ **DF** = discharge damper, FC fan$_3$ **VA** = vane axial fan w/ variable pitch$_4$ **VS** = variable speed drive$_5$				
Return air rate (CFM/unit)				
Economizer **W** = Water$_1$ **A** = Air$_2$				
Serves Area ID # Enter area ID number or A for all areas				

Note: For all multi-zone control systems (package and built-up), complete the “HVAC Multi-Zone Control” table on the following page. This applies to :

Package Systems = PMZ, PVAV
Built Systems = VAV, MZS, DDS

Comments ____________________

____

____

____

HVAC Multi-Zone Control System # or Ltr				
Are perimeter/interior controls the same? (If yes, only complete Perimeter Zone Controls section.)	Y N	Y N	Y N	Y N
Perimeter Zone Controls				
Terminal type **CO** = cooling-only, VAV1 **RH** = reheat2 **PF** = parallel fan-powered3 **SF** = series fan-powered4 **I** = induction (non-powered)5 **DD** = dual duct or multizone dampers6				
Reheat Source: **NA** = none1 **E** = Electric2 **HW** = Hot water3				
Supplemental Heat Source: **NA** = none1 **EB** = Electric baseboard2 **HB** = Hot water baseboard3				
Terminal minimum volume (% of peak)				
Interior Zone Controls				
Terminal type: Use same codes listed above				
Reheat Source: Use same codes listed above				
Terminal minimum volume (% of peak)				

Built-up Heating Equipment	1	2	3	4
Equipment Type: **F** = Furnace1 **STMB** = Steam Boiler2 **BASE** = Baseboard Heating3 **HHP** = Hydronic Heat Pump4 **HWB** = Hot Water Boiler5 **OT1** = Other6 ___________________				
Fuel Type: **E** = Electricity1 **N** = Natural Gas2 **F** = Fuel Oil3 **L** = LPG4 **W** = Wood5				
Equipment manufacturer				
Model number				
Estimated year of installation				
Number of Units				
Backup or Second Fuel Type				
Output (Capacity kBtu/hr/unit)				
Efficiency: (% or COP for HHP)				
(HSPF for HHP)				
Backup	Y N	Y N	Y N	Y N
Serving Distribution Systems #				

Built-up Cooling Equipment	1	2	3	4
Equipment Type: **CENT** = Centrifugal1 **RECP** = Reciprocating2 **SABS** = Absorption steam3 **SCRW** = Screw Compressor4 **HHP** = Hydronic Heat Pump5 **GABS** = Absorption, direct fired gas6 **EC** = Evaporative Cooler7 **OT1** = Other8_______________				
Fuel Type: **E** = Elect1 **N** = Natural Gas2 **F** = Fuel Oil3 **L** = LPG4 **CH** = Chilled Water5				
Number of Units				
Compressor: Volts				
Amps				
Phase				
kW = (V × A × ∨ Phase × 0.85)/1000				
Equipment Manufacturer				
Model number				
Estimated year of installation				
Capacity tons/unit)				
Efficiency: kW/ton or EER for HHP)				
or COP				
VSD Compressor ?	Y N	Y N	Y N	Y N
Serving Distribution Systems #				

Circulation Pumps Built-up)	# __	# __	# __	# __
Use Type: **CW** = Chilled Water1 **HW** = Hot Water2 **CHW** = Chilled/Hot Water3 **CN** = Condenser4				
Number of units				
Pump power (hp)				
Motor Type: **O** = One Speed1 **T** = Two Speed2 **V** = Variable3				
Backup equipment?	**Y N**	**Y N**	**Y N**	**Y N**
Serves heating equipment #				
Serves cooling equipment #				

Heat Rejection Built-up)	# __	# __	# __	# __
Type: **AC** = Air Condenser1 **EC** = Evaporative Condenser2 **ACP** = Air Cond w/pre-cooler3 **CT** = Cooling Tower4				
Number of units				
Fan power (hp)				
Fan Control: **O** = One Speed1 **T** = Two Speed2 **V** = Variable3				
Serves cooling equipment#				
Backup Equipment?	**Y N**	**Y N**	**Y N**	**Y N**

Exhaust Fans	#__	#__	#__	#__	#__
Number of units					
Fan power (HP / unit)					
Fan capacity (CFM / unit)					
Serves Area ID #					

Water Heating Equipment	# _____	# _____	# _____

Fuel Type: **E** = Electricity1 **N** = Natural Gas2 **F** = Fuel Oil3 **L** = LPG4 **W** = Wood5 **S** = Solar6 **H** = Heat Recovery7 **O** = Other8______			
Water Heating Equipment Type: **IWH** = Individual Water Heater1 **I** = Instantaneous (Tankless)2 **PS** = Purchased Steam Heat Exchanger3 **HP** = Heat Pump Water Heater4 **PHW** = Purchased Hot Water5 **PB** = Process Boiler6 **SHB** = Space Heating Boiler7 **B** = Boiler Water Heating Only8			
If water is heated by a Process boiler - Enter Boiler #			
If water is heated by a Space Heating Boiler - Enter Boiler #			
Number of units			
Heating Capacity (kBtu/hr or kW)			
Tank Capacity (Gallons)			
Is the hot water tank insulated?	**Y N**	**Y N**	**Y N**
Are hot water pipes insulated?	**Y N**	**Y N**	**Y N**
Recirculation pump power (hp) - Enter zero for no pump			
Average hot water temperature (F)			
Age of equipment?			

Outdoor Lighting	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Use Type: **F** = Facade1 **L** = Landscape2 **S** = Security3 **D** = Advertising4 **P** = Parking5 **X** = Exit6							
Control Type **O** = On/Off-Switch1 **TC** = Timeclock2 **PC** = Photo Cell3 **EMS** = Energy-Mangt-System4							
Lamp Type: **F** = Fluorescent Tube1 **UT** = Fluorescent U-tube2 **CF** = Compact Fluoresent3 **OF** = Other Flourescent4 **I** = Incandescent5 **N** = Neon6 **EL** = LED7 **MV** = Mercury Vapor8 **MH** = Metal Halide9 **H** = High Pressure Sodium Vapor10 **L** = Low Pressure Sodium Vapor11							
For Fluorescent Tubes: Tube 2' 4' 6' 8'							
Dia T8 T9 T10 T12							
Watts per Lamp							
Number of Lamps per Fixture							
Ballast Type: **S** = Standard1 **H** = High Efficiency2 **E** = Electronic3	S H E	S H E	S H E	S H E	S H E	S H E	S H E
Number of Ballasts per Fixture							
Hours per Week							
Total Number of Fixtures							
Field Notes: (Counts)							

Comments ______________________________

____

____

____

Lighting

Indoor Lighting	1	2	3	4	5	6	7
Use Type: **A** = Area1 **T** = Task2 **D** = Advertising3 **X**= Exit4							
Mounting: **R** = Recessed1 **S** = Suspended2 **O** = Other3	R S O	R S O	R S O	R S O	R S O	R S O	R S O
Reflector Yes or No	Y N	Y N	Y N	Y N	Y N	Y N	Y N
Vented to return air? Yes or No	Y N	Y N	Y N	Y N	Y N	Y N	Y N
Control Type: **O** = On/Off-Switch1 **TC** = Time-Clock2 **DM** = Dimmer3 **OS** = Occupancy-Sensor4 **DL** = Daylighting controls5 **EMS** = Energy-Management-System6							
Lamp Type **F** = Fluorescent Tube1 **UT** = Fluorescent U-tube2 **CF** = Compact Fluoresent3 **OF** = Other Flourescent4 **I** = Incandescent5 **N** = Neon6 **EL** = LED7 **MV** = Mercury Vapor8 **MH** = Metal Halide9 **H** = High Pressure Sodium Vapor10 **L** = Low Pressure Sodium Vapor11							
For Fluorescent Tubes: Tube 2' 4' 6' 8'							
Dia T8 T9 T10 T12							
Watts per Lamp							
Number of Lamps per Fixture							
Ballast Type: **S** = Standard1 **H** = High Efficiency2 **E** = Electronic3	S H E	S H E	S H E	S H E	S H E	S H E	S H E
Number of Ballasts per Fixture							
Hours per Week							
Total Number of Fixtures							
Area ID #							
Field Notes: (Counts)							

Office Equipment

Item #	Equipment ID	Equipment Name	kW	Avg hrs per week	Total # of units	Area ID
1	OF1	PC w/color monitor[1] *140*				
2	OF2	PC w/monochrome monitor[2] *115*				
3	OF3	Laptop Computer[3] *40*				
4	OF4	Monitor - color (MF terminal) [4] *60*				
5	OF5	Monitor - mono (MF terminal) [5] *30*				
6						
7						
8	OF6	Printer - Ink Jet[6] *85*				
9	OF7	Printer - Laser[7] *140*				
10	OF8	Printer - Dot matrix[8] *30*				
11						
12						
13	OF9	Typewriter[9] *120*				
14	OF10	FAX machine[10] *90*				
15	OF11	Point-of-sale terminals[11] *100*				
16	OF12	Cash Registers[12] *100*				
17	OF16	Adding Machine[13] *10*				
18	OF17	Answering Machine[14] *15*				
19	OF18	Hole Punch[15] *600*				
20	OF19	Shredder[16] *600*				
21						
22						
23						
24	OF13	Small Copier[17] *850*				
25	OF14	Medium Copier[18] *1425*				
26	OF15	Large Copier[19] *2400*				
27						
28	OF50	Computer - Mainframe[20]				
29	OF51	Printer - Mainframe[21]				
30	OF52	Workstation[22]				
31	OF53	Telephone System[23]				
32	OF54	Blueprint Machine[24]				
33	OT55	Other (describe) [25] _________				
34	OT56					
35	OT57					
36	OT58					

Miscellaneous Equipment

Item #	Equip ID	Equipment Description	Fuel Type	kW / KBtuh	Avg hrs per week	Total # of units	Area ID
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Note: [For site connected load check sheet] Use 0.3kW for equipment with unknown capacities

ID	**Building Equipment**		ID	**Electronics**		ID	**Shop**	
B1	Air Hand Dryers[1]		E1	Broadcasting Equipment[25]		S1	Electric Crane[44]	
B2	Alarm System[2]		E2	Radio (plug-in) [26]		S2	Electric Transport[45]	
B3	Automatic Door[3]		E3	Stereo System[27]		S3	Electric Vehicles[46]	
B4	Battery Charger[4]		E4	Television[28]		S4	Forklift[47]	
B5	Clock \ Wall Clock[5]		E5	Video Recorder (VCR) [29]		S5	Forklift Charger[48]	
B6	Janitorial Equipment[6]					S6	Hand Truck[49]	
B7	Vacuum Cleaner[7]					S7	Portable Shop Tools[50]	
B9	Video Camera (security)[8]			**Service/Retail**		S8	Shop Equipment[51]	
B8	Water Coolers (Drinking) [9]		R1	ATM Machine[30]		S9	Soldering Gun or Iron[52]	
			R2	Change Machine[31]		S10	Welder[53]	
	Medical/Hospital		R3	Conveyor (check-out) [32]				
M1	Autoclave[10]		R4	Film Processing[33]			**Laundry**	
M2	Bath[11]		R5	Photo Equipment[34]		L1	Clothes Dryer, Res[54]	
M3	Cat Scan[12]		R6	Pinball or Video Game[35]		L2	Clothes Washer, Res[55]	
M4	Centrifuge[13]		R7	Vending Machine (Refrigerated) [36]		L3	Comm Dryer[56]	
M5	Chromatograph, analyzer[14]		R8	Hair Dryers[37]		L4	Comm Washer[57]	
M6	Cytometer, blood analyzer[15]		R9	Exercise Equipment[38]		L5	Dry Cleaning Unit[58]	
M7	Dentist Chair[16]		R10	Gas Pump[39]		L6	Sewing Machine[59]	
M8	EKG Machine[17]		R11	Industrial Compactor[40]				
M9	Hot Plate[18]		R12	Vending Machine (Non-Refrigerated) [41]			**Space Comfort**	
M10	Incubator[19]		R13	Purified Water Vending Machine[42]		C1	Air Cleaner[60]	
M11	Laboratory Incubator[20]					C2	Ceiling or Portable Fan[61]	
M12	Laboratory Oven[21]					C3	Dehumidifier[62]	
M13	Laboratory, other equip. [22]			**Other**		C4	Humidifier[63]	
M14	Sterilizer[23]		OT	Specify Under Equip. Name[43]		C5	Portable Heater[64]	
M15	X-Ray[24]							

Cooking / Food Service Equipment: Area ID

Item	Code	Equipment Name	Fuel	kW / kBtuh	Avg hrs per Week	Total # of Units
1						
2	OV	Oven[1]				
3	ST	Stove[2]				
4	GR	Griddle[3]				
5						
6						
7						
8	CB	Charbroiler[4]				
9	FR	Fryer[5]				
10	IB	Infrared Broiler[6]				
11	SM	Steamer[7]				
12	FW	Food Warmer[8]				
13	SP	Soup Pots[9]				
14						
15						
16						
17	CM	Coffee Maker[10]				
18	MW	Microwave[11]				
19	FB	Flash Bake Oven[12]				
20						
21						
22	DW	Dishwasher[13]				
23	GD	Garbage Disposal[14]				
24	TS	Toaster[15]				
25	TC	Trash Compacter[16]				
26	IC	Ice Cream Dispenser[17]				
27	SD	Drink Dispenser (Refrigerated)[18]				
28	OT	Other (describe)[19] _____________				
29						
30						
31						

Refrigerator/Freezers

Item	Code	Equipment Name	kW	Total # of Units
1	1D	Single-door[1]		
2	2D	Two-door[2]		
3	3D	Three-door[3]		
4	OT	Other (describe)[4] _____________		
5	UC	Under counter[5]		
6	CH	Chest[6]		

Self-Contained Commercial Refrigeration Equipment

Item #	Equip Code	Length feet	# of Glass Doors	Amps @ 120V	*Amps @ 208V	Total # of units	Area ID #
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

∗Note: Amps listed should not include defrost heater amperage.

Self-Contained Refrigeration Equipment Codes

Typical Store Type	Equip Code	Description
Supermarket:	**GD**$_1$	Glass door beverage cases (e.g. vendor supplied) from 2 to 4 doors.
	OU$_2$	Open upright display cases (pizza, juice, etc.) usually in 4,5,6 ft increments
	IC$_3$	Island cases (cheese, sometines produce or juice), from 8 to 16 ft long.
	SC$_4$	Service cases (bakery, sometimes deli) from 4 to 8 ft.
	CD$_5$	Closed door storage cases (bakery), one to three doors.
Convenience Stores:	**UG**$_6$	Upright glass door cooler cases and freezer cases, from 1 to 3 doors
	CF$_7$	Coffin type glass top freezer cases (usually ice cream), typically 6 or 8 ft.
	IM$_8$	Ice vending machines and storage boxes.
All Types:	**OT**$_9$	Other: self-contained refrigeration not listed above.

Comments ______________________________

Remote Refrigeration Equipment

Display Cases	**Ice Cream & Frozen Juices**	**Frozen Food, Meat, & Bakery Cases**	**Fresh Meat & Upright Open Deli-Meat Cases**	**Dairy, Produce, Beverage, & Glass Front Cases**
Case Temperatures, °F	**-35**	**-25**	**+10**	**+20**
Single-deck cases Length, lineal ft.	__ __ __ __	__ __ __ __	__ __ __ __	__ __ __ __
Multi-deck cases Length, lineal ft.	__ __ __ __	__ __ __ __	__ __ __ __	__ __ __ __
Double-Wide Island type cases Length, lineal ft.	__ __ __ __	__ __ __ __	__ __ __ __	__ __ __ __
Glass door type cases # of doors	__ __ __ __	__ __ __ __	__ __ __ __	__ __ __ __
All case types: Defrost control type **E** = Electric$_1$ **G** = Hot Gas$_2$ **T** = Timed-off$_3$ **N** = None$_4$	__	__	__	__

Walk-Ins and Preparation Areas	**Freezers (0 to -10 °F)**	**Coolers (30 to 40 °F)**	**Prep Areas (50-55 °F)**
Floor Area, ft^2			
Defrost control type: **E** = Electric$_1$ **G** = Hot Gas$_2$ **T** = Timed-off$_3$ **N** = None$_4$			
Strip curtains?	Y N	Y N	Y N

Compressors	**-35 to -25**	**+10 to +20**	**Prep Areas**
System type: **C** = Conventional$_1$ **T** = Twins (2 equal size)$_2$ **M** = Multiplex$_3$ **O** = Other$_4$_________			
Number of units			
Manufacturer code: **S** = Copeland Std.$_1$ **D** = Copeland Discus$_2$ **C** = Carlyle$_3$ **O** = Other$_4$_______			
Total horsepower			
Variable speed compressors?	Y N	Y N	Y N
Heat recovery type: **N** = None$_1$ **SH** = Space heating$_2$ **WH** = Water heating$_3$ **R** = Reheat$_4$ **O** = Other$_5$			
Subcooling	Y N	Y N	Y N
Floating Head Pressure Control?	Y N	Y N	Y N

	# __	# __	# __
Condenser type: **AC** = Air-cooled$_1$ **ACP** = Air-cooled w/ precooler$_2$ **EC** = Evaporative cooled$_3$ **WC** = Water-cooled$_4$			
Total fan horsepower (all types)			
Pump motor hp (evap / liquid cooled only)			

Motors/Engines

Item #	Motor Service	Drive Type	Size (hp)	# of Units	High Efficiency	Load Type	ASD?	Average Age	Control Type	Avg hrs per week	Area ID #
1					Y N	C V I	Y N				
2					Y N	C V I	Y N				
3					Y N	C V I	Y N				
4					Y N	C V I	Y N				
5					Y N	C V I	Y N				
6					Y N	C V I	Y N				
7					Y N	C V I	Y N				
8					Y N	C V I	Y N				
9					Y N	C V I	Y N				
10					Y N	C V I	Y N				
11					Y N	C V I	Y N				
12					Y N	C V I	Y N				
13					Y N	C V I	Y N				
14					Y N	C V I	Y N				
15					Y N	C V I	Y N				
16					Y N	C V I	Y N				
17					Y N	C V I	Y N				
18					Y N	C V I	Y N				
19					Y N	C V I	Y N				
20					Y N	C V I	Y N				
21					Y N	C V I	Y N				
22					Y N	C V I	Y N				
23					Y N	C V I	Y N				
24					Y N	C V I	Y N				
25					Y N	C V I	Y N				

Motor Equipment Codes

Motor Service:		Drive Type:	Load Type:	Control Type:
P : Pump$_1$	**S** : Separation$_7$	**AC**$_1$	**C** : Constant$_1$	**S** : On/Off Switch$_1$
F : Fan$_2$	**V**: Vertical Transport$_8$	**DCS** : DC w/ SCR$_2$	**V** : Variable$_2$	**T** : Throttled$_2$
B : Blower$_3$	**O** : Other$_9$ __ __ __ __ __ __ _	**DCM** : DC w/ MGS$_3$	**I** : Intermittent$_3$	**M** : Mechanical VSD$_3$
M: Material Handling$_4$		**EG** : Nat gas driven$_4$		**E** : Electronic VSD$_4$
T : Machine Tool$_5$		**FG** : Fossil driven$_5$		**C** : Constant Volume$_5$
G : Grinding/milling$_6$				

Air Compressors

Item #	Comp Type	Contrl Type	Appl Type	Drive Type	# of Units	Size (Hp)	HiEff Motor?	ASD?	Avg Age	Oper Hours per/Wk	Area ID #
1							Y N	Y N			
2							Y N	Y N			
3							Y N	Y N			
4							Y N	Y N			
5							Y N	Y N			
6							Y N	Y N			
7							Y N	Y N			
8							Y N	Y N			
9							Y N	Y N			
10							Y N	Y N			
11							Y N	Y N			
12							Y N	Y N			
13							Y N	Y N			
14							Y N	Y N			
15							Y N	Y N			
16							Y N	Y N			
17							Y N	Y N			
18							Y N	Y N			
19							Y N	Y N			
20							Y N	Y N			

Air Compressor Codes

Compressor Type	Control Type	Application Types	Drive Type
RTD: Reciprocating (Two-state, Double-acting)$_1$	**S**-Start/Stop$_1$	**C**-Cleaning$_1$	**E**-Energy Efficient AC$_1$
RST: Reciprocating (Single-stage, Double-acting)$_2$	**L**-Load/Unload$_2$	**T**-Drives tools$_2$	**S**-Standard Efficient AC$_2$
RTS: Reciprocating (Two-stage, Single-acting)$_3$	**M**-Multi-step$_3$	**O**-Other$_3$	**D**-DC$_3$
RSS: Reciprocating (Single-stage, Single-acting)$_4$	**V**-VSD Throttling$_4$		**G**-Engine$_4$
ST: Rotary Screw (Two-stage)$_5$	**P**-Turn/Poppet Valves$_5$		**T**-Steam Turbine$_5$
C: Centrifugal$_6$	**T**-Throttling$_6$		**O**-Other$_6$
O: Other$_7$	**O**-Other$_7$		

Process Equipment:

Eqp No.	Proc Type	Product Produced	Boiler #	# of units	Average Capacity kBtu/h	Fuel Type 1: Type	Fuel Type 1: % of Annual Btu	Fuel Type 2: Type	Fuel Type 2: % of Annual Btu	Avg hrs per week	Area ID #
1							%		%		
2							%		%		
3							%		%		
4							%		%		
5							%		%		
6							%		%		
7							%		%		
8							%		%		
9							%		%		
10							%		%		

Process Boilers

For the water/steam boilers used at this facility, identify the type and number of boilers, the per unit capacity of the boilers, the units that the capacity is recorded in, the primary fuel used, and the percentage of the water/steam that is used for: process, domestic hot water, and space heating.

		Boiler #1	Boiler #2	Boiler #3	Boiler #4	Boiler #5
Boiler Type: **W** - Hot water$_1$ **S** - Steam$_2$						
Efficiency (%)						
Quantity						
Capacity						
Units (kW / kBtu)						
Primary Fuel Type: **E** = Electricity$_1$ **N** = Natural Gas$_2$ **F** = Fuel Oil$_3$ **L** = LPG$_4$ **C** = Coal/Coke$_5$ **W** = Waste Oil$_6$ **D** = Diesel$_7$ **G** = Gasoline$_8$ **O** = Other$_9$:________						
Secondary Fuel Type						
% of Boiler Output to Each End Use:	Process					
Note: If % total not = 100%,	Space Heating					
explain why in comments.	Service Hot Water					
Area ID # (Enter 99 if Outside Any Area)						

Comments

____

____

____

____

Process Equipment Codes

Heat Processing:		**Pulping:**		**Drying/Curing/Baking:**	
Direct Fired Gas Heating	DFGH$_{1}$	Batch Digesters	DIGST$_{33}$	Ovens	OVENDCB$_{63}$
Direct Fired Oil Heating	DFOH$_{2}$	Stock Refiners	STKREF$_{34}$	Microwave	MICRODCB$_{64}$
Blanchers	BLNCH$_{3}$	**Paper Preparation:**		Infrared	IR$_{65}$
Microwave	MICROHP$_{4}$	Pulpers	PULP$_{35}$	Electric Resistance	ELRES$_{66}$
Sterilizers	STER$_{5}$	Refiners	REFNR$_{36}$	Steam from Process Boiler	STM$_{67}$
Pasteurizers	PAST$_{6}$	Stock Mixers	STKMXR$_{37}$	Ultraviolet	UV$_{68}$
Induction Heating	INDCTHTG$_{7}$	**Separation and Distillation:**		Kiln	KILN$_{69}$
Induction Melting	INDCTMLT$_{8}$	Thermal Distillation Column	THRMDC$_{38}$	Radio Frequency	RFDCB$_{70}$
Radio Frequency	RFHP$_{9}$	Freeze Concentration	FRZCON$_{39}$	Electron Beam	EBDCB$_{71}$
Indirect Resistance	INDIRES$_{10}$	Vacuum Condensation	VACCON$_{40}$	**Refrigeration/Freezing:**	
Direct Resistance	DIRRES$_{11}$	Membrane Separation	MEMSEP$_{41}$	Forced Air Cooling	FORAIR$_{72}$
Encased Resistance	ENCRES$_{12}$	Pressure Swing Absorption	PSA$_{42}$	Blast Freezing	BLSTFRZ$_{73}$
Plasma Processing	PLSMHP$_{13}$	Vacuum Concentration	VACCNTR$_{43}$	Hydrocooling	HYDRCL$_{74}$
Electric Arc Furnace	ELARCFRN$_{14}$	Ultra Filtration	ULTRAFLT$_{44}$	Belt Freezing	BLTFRZ$_{75}$
Ion Nitriding	IONNIT$_{15}$	Reverse Osmosis	REVOS$_{45}$	Plate Freezing	PLTFRZ$_{76}$
Laser Hardening	LASER$_{16}$	Evaporators	EVAP$_{46}$	Vacuum Cooling	VACCL$_{77}$
Cupola	CUPOLA$_{17}$	**Solid-Liquid Extraction:**		Immersion Freezing	IMMFRZ$_{78}$
Dehydration:		Single Stage Extractors	SSEXT$_{47}$	**Mixing and Emulsification:**	
Convection Dryer	CONVDR$_{18}$	Multi-Stage, Static Bed Extractors	MLTEXT$_{48}$	Pressure Homogenizers	PRSHOM$_{79}$
Infrared Dryer	IRDR$_{19}$	Continuous Moving-Bed Extractors	CONBED$_{49}$	Ultrasonic Emulsificatino Devices	ULTRAEMD$_{80}$
Electric Resistance Drying	ELRESDH$_{20}$	**Plastic Molding:**		**Fiber Preparation:**	
Microwave Dryer	MICRODH$_{21}$	Injection Molding	INJMLD$_{50}$	Dye Tanks	DYE$_{81}$
Material Preparation:		Extrusion Molding	EXTMLD$_{51}$	**Crystallization:**	
Arc Welding	ARCWLD$_{22}$	Blow Molding	BLWMLD$_{52}$	Oil Winterization	OILWNTR$_{82}$
Laser Cutting	LASERCT$_{23}$	Rotational Molding	ROTMLD$_{53}$	Freeze Concentration	FRZCONC$_{83}$
Water Jet Cutting	WTRJET$_{24}$	Compression Molding	COMPMLD$_{54}$	Ice Crystallization	ICECRYS$_{84}$
Electron Beam Welding	EBWMP$_{25}$	Thermoforming	THRMFRM$_{55}$	Lactose Crystallization	LACCRYS$_{85}$
Laser Welding	LASERWLD$_{26}$	**Process Cooling:**		Fat Crystallization	FATCRYS$_{86}$
Plasma Cutting	PLSMMP$_{27}$	Reciprocating Chillers	RECIP$_{56}$	**Screening and Separation:**	
Filtration:		Centrifugal Chillers	CENT$_{57}$	Froth Floatation Baths	FRTH$_{87}$
Pressure Filters	PRESFLT$_{28}$	Direct Expansion Compressors	DXCOMP$_{58}$	**Exploration and Drilling:**	
Vacuum Filters	VACFLTR$_{29}$	**Washing and Drying:**		Engine Driven Boring Equipment	ENGBOR$_{88}$
Finishing:		Rotary Kilns	ROTKLN$_{59}$	**Pumping:**	
Ovens	OVENF$_{30}$	Cascade Dryer	CASCDR$_{60}$	Engine Driven Pumps	ENGPMP$_{89}$
Electroplating	ELPLT$_{31}$	Fluidized Bed Dryer	FBD$_{61}$	**Compressing:**	
Hot Dip Galvanizing	HDG$_{32}$	Suspension Dryer	SUSPDR$_{62}$	Combustion Turbine Compressor	COMTUR$_{90}$

On-Site Survey Notes & Comments

Operation, Occupancy and HVAC Secondary Schedules

Operation Schedule (define a typical week)

Day Types *(up to 3 types)*	**Applicable Days**	**Business Hours**
Standard Day	M T W T F S S H	from __ __ to __ __
Non-Standard Day	M T W T F S S H	from __ __ to __ __
Closed	M T W T F S S H	

Occupancy Schedule

Maximum number of occupants in one hour? __ __ __ __ __(Max Occup)

Day Type	Start Hour	% of Max Occup	Stop/ Start Hour	% of Max Occup	Stop/ Start Hour	% of Max Occup	Stop/ Start Hour	% of Max Occup	Stop/ Start Hour	% of Max Occup
Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Cooling Temperature Schedule

Day Type	Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F
Std	00									
Non-Std	00									
Closed	00									

Heating Temperature Schedule

Day Type	Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F	Stop/ Start Hour	Temp °F
Std	00									
Non-Std	00									
Closed	00									

Equipment Secondary Schedules

Complete these schedules if there is seasonal variation in equipment usage.

Day Type	Start Hour	% of Equip On	Stop/ Start Hour	% of Equip On	Stop/ Start Hour	% of Equip On	Stop/ Start Hour	% of Equip On	Stop/ Start Hour	% of Equip On

Indoor Lighting Schedule

Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Outdoor Lighting Schedule

Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Office Equipment

Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Miscellaneous Equipment Schedule

Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Cooking Schedule

Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Process Equipment Schedule

Std	00	%		%		%		%		%
Non-Std	00	%		%		%		%		%
Closed	00	%		%		%		%		%

Appendix B

Decision-Maker Survey Instruments

Participants

SAVINGS THROUGH DESIGN PROGRAM

PARTICIPANT DECISION-MAKER SURVEY

San Diego Gas & Electric Company 1996

8/28/96

Survey ID Number ____________________

Site Number (RP#) _________ OR ☐ Covers multiple sites/corporate Decision Maker

Contact Person ____

Title ____

Address ☐ Check if same as on Contact Sheet (ask for confirmation)

____
(City, State, Zip Code)

Telephone Number ____

Date of Interview ____

Disposition of Call ____

Hello, my name is ___________________. I'm calling on behalf of San Diego Gas & Electric Company.

May I please speak to _____________________ ? (*Decision Maker. The decision-maker was identified in the on-site recruiting process or through inspection of participant records)*

Interviewer: If Decision Maker is not available, schedule a callback.

Callback: __________________________(Date)
__________________________(Time)

If Decision Maker is available:

Hello, my name is ___________________. I'm calling on behalf of San Diego Gas & Electric Company. SDG&E is interested in working with commercial building owners and developers to improve the energy efficiency of new buildings and renovations. Because you participated in SDG&E's Savings Through Design Program, we are very interested in receiving feedback about the program from you. We recently conducted an on-site survey of your _______________ (*name of project*) project at ______________ (*address*), which participated in the program, and would like to follow up on that survey by asking you a few questions relating to energy efficiency.

The questions I will be asking you relate to the decisions that were made to participate in the Savings Through Design Program and to purchase and install the energy efficient equipment. Are you the best person to talk to?

- ☐ Yes. *Continue*
- ☐ No. Is there someone else we can contact? *(Read)*
  Name ________________________________
  Position ________________________________
  Phone # ________________________________
  Thank you very much for your time. *(Read)*

This survey will take about five to ten minutes. Is now a good time?

- ☐ Yes. *Continue*
- ☐ No.*Reschedule*

1. How many new construction and renovation projects have you been involved with in the past three years?

   Number of Projects: ¦__¦__¦__¦
   Total Square Footage: ¦__¦__¦__¦__¦__¦__¦__¦__¦

2. Was the *(name of project)* project:

   ☐ To be fully occupied by the site owner (owner-occupied)
   ☐ To be leased by the owner (own, do not occupy)
   ☐ To be partially occupied by owner and partially leased (partially owner occupied)
   ☐ Built for resale (Spec. built)
   ☐ Other (please explain)

   ____

   ____

3. Please rank the following factors according to their importance in affecting your plans for constructing new buildings or renovating existing buildings. (1 indicates the most important, etc.)

   ☐ First cost or construction cost
   ☐ Energy efficiency
   ☐ Tenant comfort
   ☐ Design/attractiveness
   ☐ Other (please specify ____________________________)

4. Which financial methods do you typically use to evaluate energy efficiency improvements for your projects? *(If more than one answer is given, rank the answers based on order, e.g., "1" for highest priority.)*

   ☐ Simple payback *(Go to Question 4a)*
   ☐ Internal rate of return *(Go to Question 4b)*
   ☐ Life cycle cost *(Go to Question 4c)*
   ☐ First cost *(Go to Question 5)*
   ☐ Other (please explain) _____________________________ *(Go to Question 5)*
   ☐ Don't know *(Go to Question 5)*

4a. What payback period in years do you normally require in order to consider an energy investment cost effective?__________ years (*Go to Question 5)*

4b. What rate of return do you normally require in order to consider an energy investment cost effective? ______% *(Go to Question 5)*

4c. What discount rate do you use in determining the life-cycle cost of various equipment options? ______% *(Go to Question 5)*

5. Are you familiar with the Title 24 energy efficiency standards and their requirements?

- ☐ Yes *Go to Question 6*
- ☐ No *Go to Question 8*

If No, who is the person responsible for making sure your project meets these requirements?

Contact: __________________ *Phone #:* ________________

Title: ____

6. Would you say the newly constructed or renovated commercial buildings you've been involved with in the past three years…

- ☐ Are *usually* designed and built to *just meet* the Title 24 energy efficiency standards
- ☐ Are *sometimes* designed to achieve *greater* energy efficiency than Title 24
- ☐ Are *usually* designed to achieve *greater* energy efficiency than Title 24
- ☐ Don't know

7. There are two methods for complying with Title 24 standards: the Prescriptive method and the Performance method. What percent of your projects have used the Performance method for complying with Title 24 standards? (write answer below)

- ☐ _____ % of projects that used Performance method
- ☐ Doesn't know and can't estimate the %
- ☐ Unfamiliar with the Prescriptive/Performance terminology

8. How did you learn of SDG&E's Savings Through Design Program?

- ☐ Approached directly by SDG&E
- ☐ SDG&E information brochure
- ☐ Other owners or developers
- ☐ Design team
- ☐ Title 24 consultant
- ☐ Other (please explain) ____

9. Which of the following was the most important in influencing you to install energy efficient equipment in your building?

- ☐ Program rebate
- ☐ SDG&E's advice/recommendations
- ☐ Past experience with energy efficient equipment
- ☐ Information from non-SDG&E source. Who? ___________________________
  - ☐ Equipment literature or advertisements
  - ☐ Designer
  - ☐ Vendor
  - ☐ Other: ____

10. Our records show that you received rebates for (*READ those that are relevant*)

Energy efficient lighting equipment
High efficiency cooling equipment
Energy efficient motors and drives
Other (Specify____________________________)

10a. (*For participants who received rebates for efficient lighting*) If SDG&E's rebate had not been available for the efficient lighting you installed, how likely is it that you would have installed lighting equipment more efficient than required to satisfy Title 24?

- ☐ Definitely would have installed
- ☐ Probably would have installed
- ☐ Probably would not have installed
- ☐ Definitely would not have installed
- ☐ Don't know

10b. (*For participants who received rebates for high efficiency air conditioning equipment*) If SDG&E's rebate had not been available for the high-efficiency cooling equipment you installed, how likely is it that you would have installed cooling equipment more efficient than required to satisfy code?

- ☐ Definitely would have installed
- ☐ Probably would have installed
- ☐ Probably would not have installed
- ☐ Definitely would not have installed
- ☐ Don't know

10c. (*For participants who received rebates for high efficiency motors/drives*) If SDG&E's rebate had not been available for the high-efficiency motors or drives you installed, how likely is it that you would have installed efficient motors or drives)

- ☐ Definitely would have installed
- ☐ Probably would have installed
- ☐ Probably would not have installed
- ☐ Definitely would not have installed
- ☐ Don't know

10d. (*For participants who received rebates for other equipment*) If SDG&E's rebates had not been available for the (*other equipment specified in Question 10.*) you installed, how likely is it that you would have installed this equipment?

- ☐ Definitely would have installed
- ☐ Probably would have installed
- ☐ Probably would not have installed
- ☐ Definitely would not have installed
- ☐ Don't know

11. Do you have any other comments that you'd like me to relay to SDG&E about energy efficiency in new commercial buildings or about their programs?

____

____

____

____

____

____

____

____

____

____

Thanks for your help! Your ideas will be used to improve SDG&E programs for new commercial buildings.

Nonparticipants

SAVINGS THROUGH DESIGN PROGRAM

NONPARTICIPANT DECISION-MAKER SURVEY

San Diego Gas & Electric Company 1996

8/28/96

Survey ID Number ____________________

Site Number (RN#) _________ OR ☐ Covers multiple sites/corporate Decision Maker

Contact Person ____________________

Title ____________________

Address ☐ Check if same as on Contact Sheet (ask for confirmation)

____
(City, State, Zip Code)

Telephone Number ____________________

Date of Interview ____________________

Disposition of Call ____________________

Hello, my name is __________________. I'm calling on behalf of San Diego Gas & Electric Company.

May I please speak to ____________________ ? (*Contact person. This person should be the decision maker for the project. This should be the owner of the building, the business owner, etc. The contact person should be able to answer questions concerning the physical features of the building and the decisions that went into installing equipment into the building.)*

Interviewer: If contact person is not available, schedule a callback.

Callback: _________________________(Date)
_________________________(Time)

If contact person is available:

Hello, my name is __________________. I'm calling on behalf of San Diego Gas & Electric Company. SDG&E is interested in working with commercial building owners and developers to improve the energy efficiency of new buildings and renovation projects. We recently conducted an on-site survey of your ______________(*name of project*) project at ______________ (address), and would like to follow up on that survey by asking you a few questions relating to energy efficiency. Are you the best person to talk to?

- ☐ Yes. *Continue*
- ☐ No. Is there someone else we can contact? *(Read)*

Name ______________________________

Position ______________________________

Phone # ______________________________

Thank you very much for your time. *(Read)*

This survey will take about 5 to 10 minutes. Is now a good time?

- ☐ Yes. *Continue*
- ☐ No.*Reschedule*

1. How many new construction and renovation projects have you been involved with in the past three years?

Number of Buildings: ¦__¦__¦__¦
Total Square Footage: ¦__¦__¦__¦__¦__¦__¦__¦__¦

2. Was the *(name of project)* project:

- ☐ To be fully occupied by owner (owner-occupied)
- ☐ To be leased by owner (own, do not occupy)
- ☐ To be partially occupied by owner/partially leased (partially owner occupied)
- ☐ Built for resale (Spec. built)
- ☐ Other (please explain)

____

____

3. Please rank the following factors according to their importance in affecting your plans for constructing new buildings or renovating existing buildings. (1 indicates the most important, etc.)

- ☐ First cost or construction cost
- ☐ Energy efficiency
- ☐ Tenant comfort
- ☐ Design/attractiveness
- ☐ Other (please specify ____________________________)

4. Which financial methods do you typically use to evaluate energy efficiency improvements for your projects?

- ☐ Simple payback (*Go to Question 4a*)
- ☐ Internal rate of return (*Go to Question 4b*)
- ☐ Life cycle cost *(Go to Question 4c)*
- ☐ First Cost *(Go to Question 5)*
- ☐ Other (please explain) _________________________________ (*Go to Question 5*)
- ☐ Don't know (*Go to Question 5*)

4a. What payback period in years do you normally require in order to consider an energy investment cost effective? _________ years (*Go to Question 5*)

4b. What rate of return do you normally require in order to consider an energy investment cost effective? ____________% (*Go to Question 5*)

4c. What discount rate do you use in determining the life-cycle cost of various equipment options? ___________% (*Go to Question 5*)

5. Are you familiar with the Title 24 energy efficiency standards and their requirements?

- ☐ Yes *Go to Question 6*
- ☐ No *Go to Question 8*

  If No, who is the person responsible for making sure your project meets these requirements?

  Contact: _________________ *Phone #:* ________________

  Title: ____

6. Would you say the newly constructed or renovated commercial buildings you've been involved with in the past three years…

- ☐ Are *usually* designed and built to *just meet* the Title 24 energy efficiency standards
- ☐ Are *sometimes* designed to achieve *greater* energy efficiency than Title 24
- ☐ Are *usually* designed to achieve *greater* energy efficiency than Title 24
- ☐ Don't know

7. There are two methods for complying with Title 24 standards: the Prescriptive method and the Performance method. What percent of your projects have used the Performance method for complying with Title 24 standards? (write answer below)

- ☐ _____ % of projects that used Performance method
- ☐ Doesn't know and can't estimate the %
- ☐ Unfamiliar with the Prescriptive/Performance terminology

8. Are you familiar with the New Construction Program that SDG&E has been offering over the past two years? This program offers incentives for the installation of energy efficiency measures beyond the requirements of Title 24.

- ☐ Yes *Go to Question 9*
- ☐ No *Go to Question 13*

9. Have you participated in SDG&E's Commercial New Construction Program at any of the sites with which you've been involved over the past three years?

- ☐ Yes *Go to Question 10*
- ☐ No *Go to Question 11*

10. To what extent did you participate?

- ☐ Completed the program and received an incentive check
- ☐ Entered the program but decided not to participate
- ☐ Applied for the program but was directed to another program

  Name of program ________________________________

- ☐ Applied for the program but was rejected

11. How did you learn of SDG&E’s Commercial New Construction Program?

- ☐ Approached directly by SDG&E
- ☐ SDG&E information brochure
- ☐ Other owners or developers
- ☐ Design team
- ☐ Title 24 consultant
- ☐ Other (please explain) ____

12. How would you rate SDG&E’s requirements to qualify a project for the Title 24 Plus incentive program?

- ☐ Very easy
- ☐ Somewhat easy
- ☐ Somewhat difficult
- ☐ Very difficult

13. How much would the availability of rebate payments from SDG&E affect the selection of energy-using equipment for your new construction and renovation projects?

For lighting equipment:

- ☐ Significantly
- ☐ Somewhat
- ☐ Very little
- ☐ Not at all

For air conditioning equipment:

- ☐ Significantly
- ☐ Somewhat
- ☐ Very little
- ☐ Not at all

For motors and drives:

- ☐ Significantly
- ☐ Somewhat
- ☐ Very little
- ☐ Not at all

For other equipment

- ☐ Significantly
- ☐ Somewhat
- ☐ Very little
- ☐ Not at all

14. Do you have any other comments that you'd like me to relay to SDG&E about energy efficiency in new commercial buildings or about their programs?

____

____

____

____

____

____

____

____

____

____

Thanks for your help! Your ideas will be used to improve SDG&E programs for new commercial buildings.

Appendix C

Sample On-Site Inventory Report

Not available electronically.

Appendix D

Frequencies for Decision-Maker Surveys

Not available electronically.

Appendix E

SITEPRO User Guide

SitePro

The Site Profiler

Beta Version 1.0

August, 1998

Table of Contents

Figures

1

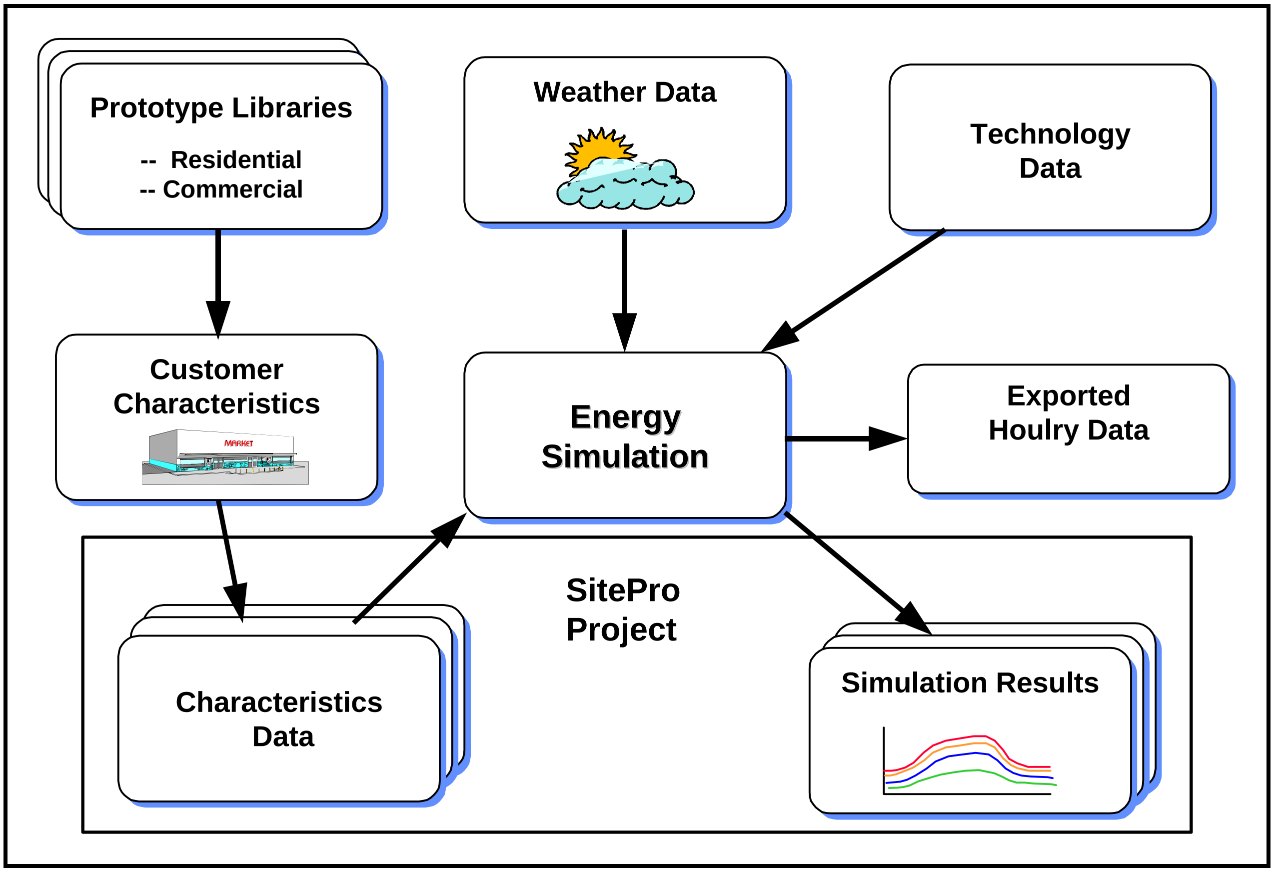
Introduction and Overview

1.1 Introduction

SitePro is a tool for developing energy load shapes for residential or commercial customers. Within SitePro, there are three modules: (a) the Residential Simulation Module, (b) the Commercial Simulation Module, and (c) the BillShaper module. The two simulation modules are represented in Figure 1-1. The main components illustrated for these modules are as follows.

- ***Prototype Library.*** The SitePro system includes libraries that contain characteristics data for prototypical residential and commercial customers. These prototypes have been carefully developed to reflect specific building types, vintages, heating and cooling equipment, and energy-use patterns for each geographic area that is represented. Users select a prototype from the library as a starting point for their analysis.
- ***Customer Characteristics.*** Users may modify selected prototype characteristics, including operating schedules, demographics, equipment types, appliance saturation levels, building size, and shell characteristics.
- ***Weather Data.*** SitePro comes with a library of TMY (typical meteorological year which is a proxy for "normal" weather) weather files for the major weather stations across the U.S. The weather library has been supplemented with actual weather data for specific years and RER's proprietary normal weather data.
- ***Energy Simulation.*** A full energy simulation is conducted for heating, cooling, and ventilation (HVAC) using DOE2. Non-HVAC uses are simulated using end-use specific algorithms. Separate calculation logic is utilized for the residential appliances and commercial equipment.
- ***SitePro Project.*** Based on data from the prototype databases, Users can create project databases. Each project database contains a list of sites, the site characteristics, as modified by the user, and the simulation results.
- ***Reports.*** Load shape results may be exported to a variety of formats, including Microsoft Access databases, Excel spreadsheets, and LDA/LDZ formats.

Figure 1-1: SitePro Residential and Commercial Modules



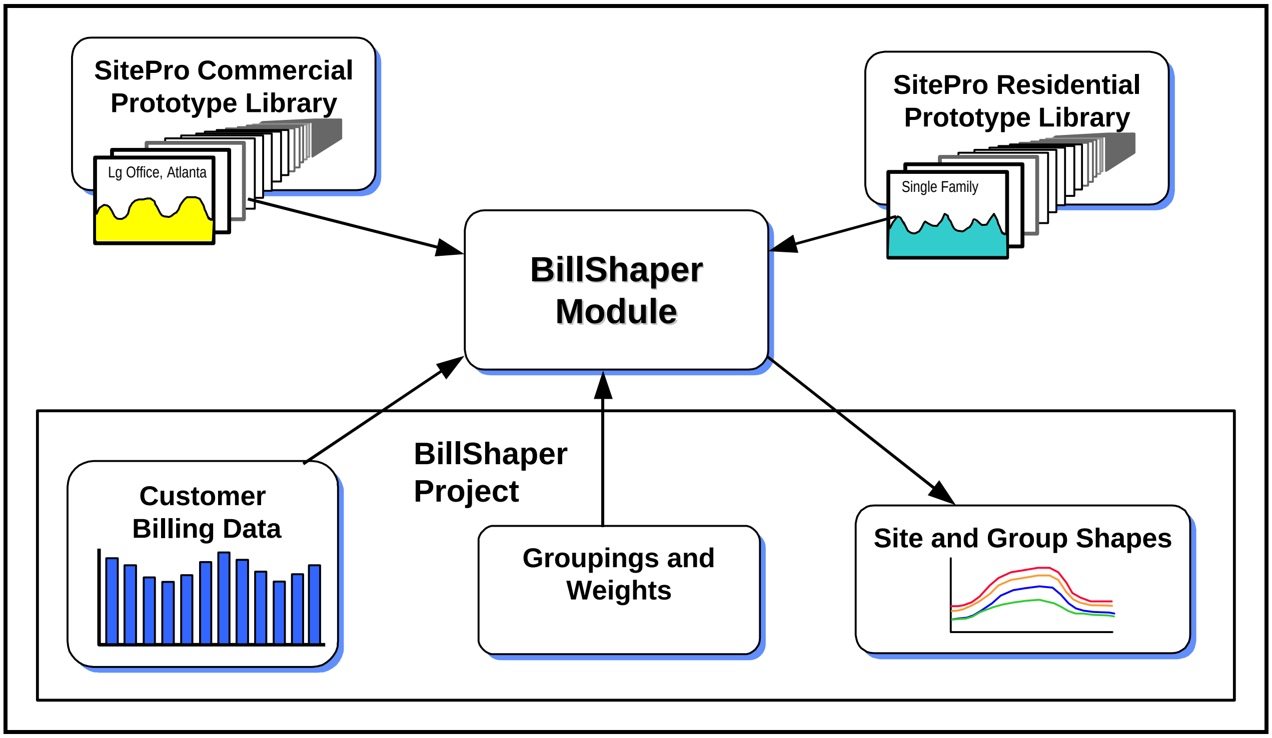
The BillShaper Module combines billing determinant data for individual sites or campuses with load shapes from the prototype libraries to create 8,760 profiles that are consistent with both sets of information. It can be thought of as a way to calibrate shapes to bills or as a way to turn billing data into load shapes. As shown in the following Figure 1-2, the main components of the module are as follows:

- ***Prototype Libraries.*** In the BillShaper module, the prototype libraries serve as a source of initial load shape estimates. Each site in a BillShaper project must be assigned a shape from one of the libraries.
- ***Groupings and Group Weights.*** Individual sites in a BillShaper project can be assigned to one of several user-defined groups. A weight can also be assigned, and the site shapes are multiplied by these weights and added to get an estimate of the group shape. Groups can be used to aggregate customer sites into a group total or to aggregate buildings in a campus into a campus total.
- ***Site Level Billing Data.*** Billing data can be entered for each site in a BillShaper project. Data that can be entered includes monthly energy, maximum demand, and billing dates. For quick analysis, a value can be entered for average monthly energy, and this value will be applied across months for which billing

data are missing. If no billing data or average values are entered, the hourly data from the prototype library are used directly.

- ***Group Level Billing Data.*** Billing data can also be entered for group totals. In this case, the group shape, which is a weighted sum of the site shapes, is adjusted to be consistent with the billing information.
- ***Reports.*** Unlike SitePro simulations, which provide data at the end-use level, BillShaper produces an 8,760 load shape as its final result. Both site-level and group-level hourly shapes are stored in the BillShaper project, and these results are available for graphical review and printing.

Figure 1-2: BillShaper Module



The remainder of this section provides a discussion of system requirements and system architecture. This is followed by three sections, applying to the Residential Module (SP-R), the Commercial Module (SP-C), and the BillShaper module, respectively.

2

Installation

2.1 System Requirements

SitePro is a client-server application. It allows remote users (the clients) to access the databases and simulation engine, which reside on server machines. The system requirements for the client (user) are as follows.

- Operating System: Windows NT 4.0
- Free disk space: 10 MB
- Dynamic Link Libraries (DLL): Microsoft Foundation Classes shared library, version 4.2 or later. The DLLs are provided with the SitePro installation.

The system requirements for the server are:

- Operating System: Windows NT 4.0
- Free Disk Space: Minimum installation depends on the databases that are installed, and can be as large as 400 MB to store the prototype and load-shape libraries.
- Memory: A minimum of 32 MB RAM
- Data Access Objects (DAO): Jet Engine drivers version 3.50 or later. The DAO drivers are provided with the SitePro installation.
- Dynamic Link Libraries (DLL): Microsoft Foundation Classes shared library, version 4.2 or later. The DLLs are provided with the SitePro installation.

2.2 Installation Instructions

The SitePro software comes on a CD with an installation program. There are three elements to be installed: the Server, the DAO objects, and the Client (user) software. The Server and DAO objects should be installed on the server by the system administrator, while the client software is installed on the users PCs. (It is also possible for the client and the server to reside on the same PC. Please refer to "Readme.htm." file on the distribution CD)

To install SitePro on the server, the system administrator does the following:

- Close all applications except Explorer.
- In the DAO\disk1 directory, double-click the Setup.exe program to install the DAO files. Follow the instructions presented by the DAO setup program.
- In the Server\disk1 directory, double-click the Setup.exe program to install the SitePro Server. Follow the instructions presented by the Setup Program.
  - -- You will be prompted for a port number. The default port number should be used unless there is a reason to change it. The same port number will be used in each client installation.
- Re-boot the machine.

To install SitePro on a client machine, do the following:

- Close all applications except Explorer.
- In the Client\Disk1 directory on the CD, double-click the Setup.exe program to run the install program.
- Follow the step-by-step instructions presented by the Setup program.
  - When prompted for the address and port number, enter the name of the machine that is running the server. If the client is running on the same PC as the server (which may be the situation with the beta version), enter the word "localhost" in server name field.
  - The default port number should be used unless there is a reason to change it. The port number must match the port number used in the server installation. Check with your network administrator for the appropriate port number.
- Re-boot the machine.

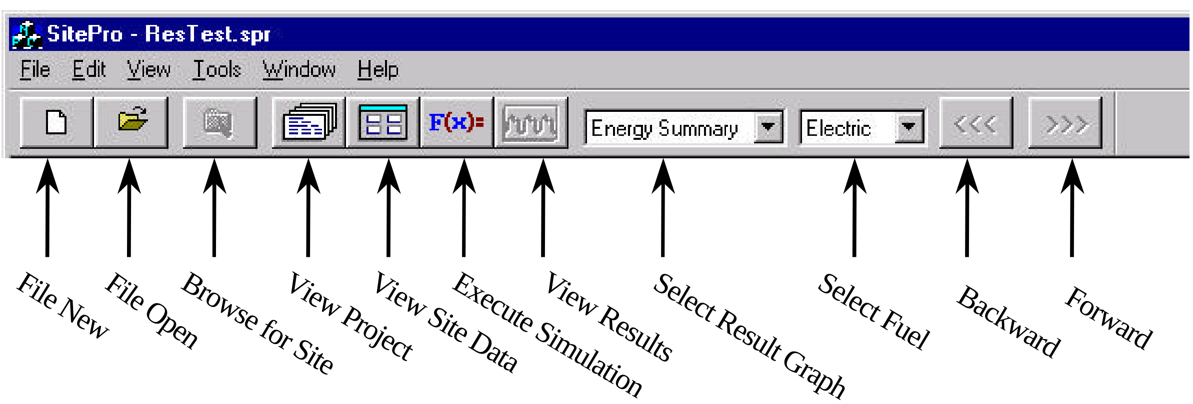
3

Using SitePro

To use SitePro effectively, it is important to understand the general system design as well as the system architecture. The design and the logic behind key actions are common to the three modules and, as a result are discussed in this overview section. Specifics details of the three options are discussed in Section 4 (Residential), Section 5 (Commercial), and Section 6 (BillShaper).

3.1 The Toolbar

The SitePro Toolbar, which is shown below, seven buttons related to navigation and file management, two drop-down boxes for results selection, and two buttons to move forward and backward through monthly results. Each button is discussed briefly below.



File New. This button results in creation of a new project file. When pressed, a dialog is presented to select the project type (residential, commercial, or BillShaper). Subsequently the user is asked for a file name for the project file. Upon completing this dialog and pressing OK, a blank project of the selected type is presented.

File Open. This button results in a standard file open dialog. The type of project that is opened depends on the file that is selected (.spr for Residential, .spc for commercial, and .bsp for BillShaper.

Browse for Site. When viewing a portfolio, this button is used to add a new site based on data from the Prototype Library. Pressing this button leads to a dialog that allows the user to examine the available libraries and select a site.

View Project. Each SitePro project involves a list of sites. This is called the Site Portfolio. When the View Project button is pressed, the window that contains the active portfolio is brought to the top view. From this view, the user selects sites to edit site data or to view site results.

View Data. When a site is selected, pressing the View Data button will active a tabbed dialog that contains the input data for that site.

Execute Simulation. For residential and commercial projects, when a site is selected, pressing the Execute button will force a simulation for that site. If the data have not changed since the last simulation, the user is asked if they want to resimulate anyway. In BillShaper, calculations are performed for all sites and groups in the portfolio, regardless of the site or group that is selected at that time.

View Results. Pressing this button results in the display of the results for the site that is selected.

Select Result Graph. This combo box provides a list of graphs that are available for review. The list contains six graphing options for simulations and three options for BillShaper projects. The options range from an annual summary page, to a full presentation of 8,760 shapes for electricity and daily usage for natural gas.

Select Fuel. This combo box provides a list of fuels, with electricity and natural gas as the two options.

Backward and Forward. The backward and forward buttons are active when the hourly and daily graphs are in view. In this case, three months are displayed at a time, and these buttons allow moving up and down in the list of months.

3.2 The Menu

The top level menu is shown above with the picture of the toolbar. The menu items and sub items are shown below. For each menu item, the shortcut key (Alt sequence) and description are provided. The functionality behind most of these menu items is discussed in the remaining parts of this chapter.

Menu	Menu Item	Shortcut	Description
File	New…	Alt FN	Create a new SitePro Project
	Open…	Alt FO	Open an existing SitePro Project
	Close	Alt FC	Close the active SitePro Project
	Compact on Close	Alt FM	Compact SitePro Project File
	Export	Alt FX	Export 8760 from Results View
	Print	Alt FP	Print the active report from Results View
	PrintAll	Alt FA	Print all reports for the active site
	MRU List	Alt F#	Open a project from the MRU list
	Exit	Alt FX	Exit SitePro
Edit	Browse	Alt EB	Browse Server databases to select a Prototype
	Delete		Delete a site from the SitePro Project
View	Toolbar	Alt VT	Show or Hide the Toolbar
	Status Bar	Alt VS	Show or Hide the Status Bar
Tools	Calibrate to Bills	Alt TC	Calibrate to bills during simulation (Commercial only)
	Save EU Details	Alt TS	Save End-use 8,760 results
	EU Detail Options…	Alt TE	Dialog to select end-uses and fuels to save
	Auto Print	Alt TP	Set automatic printing as part of simulation
	Auto Print Options…	Alt TO	Dialog to select reports to be printed
Window	Cascade	Alt WC	Cascade open windows
	Tile Horizontally	Alt WH	Tile open windows horizontally
	Tile Vertically	Alt WV	Tile open windows vertically
Help	About SitePro	Alt HA	Display About dialog

3.3 SitePro Project Files

Each SitePro module creates a type of project file that has a unique layout, depending on whether the data are for residential simulations, commercial simulations, or BillShaper runs. The extensions for these three types of files are:

- .spr for residential projects
- .spc for commercial projects
- .bsp for BillShaper projects

Each project file is built on the concept of a list of sites that are included in the project. This is called the Project Portfolio.

Project files are stored on the user's machine. Despite the extensions of these files, they are database files stored in Microsoft Access format (.mdb), and they can be viewed and edited through the Access interface, like any .mdb file.

Although they may contain data that was obtained from databases on the server, the project files are self-contained, once these data have been obtained. Since the project files are database files, there is no "File Save" action. When you change the data for a site in the project list, this change is committed to the database when the action is completed.

Opening and Creating Project Files. To open an existing project file, use the File→Open command or press the standard shortcut button for this action on the program toolbar. Select the project file that you want to work with and press OK.

To create a new project file, use the File→New command or press the standard shortcut button for this action on the program toolbar. In either case, this action will bring up a selection dialog, asking which type of project you wish to create – residential, commercial, or BillShaper. Select the desired type, provide a name for the project file, and press OK.

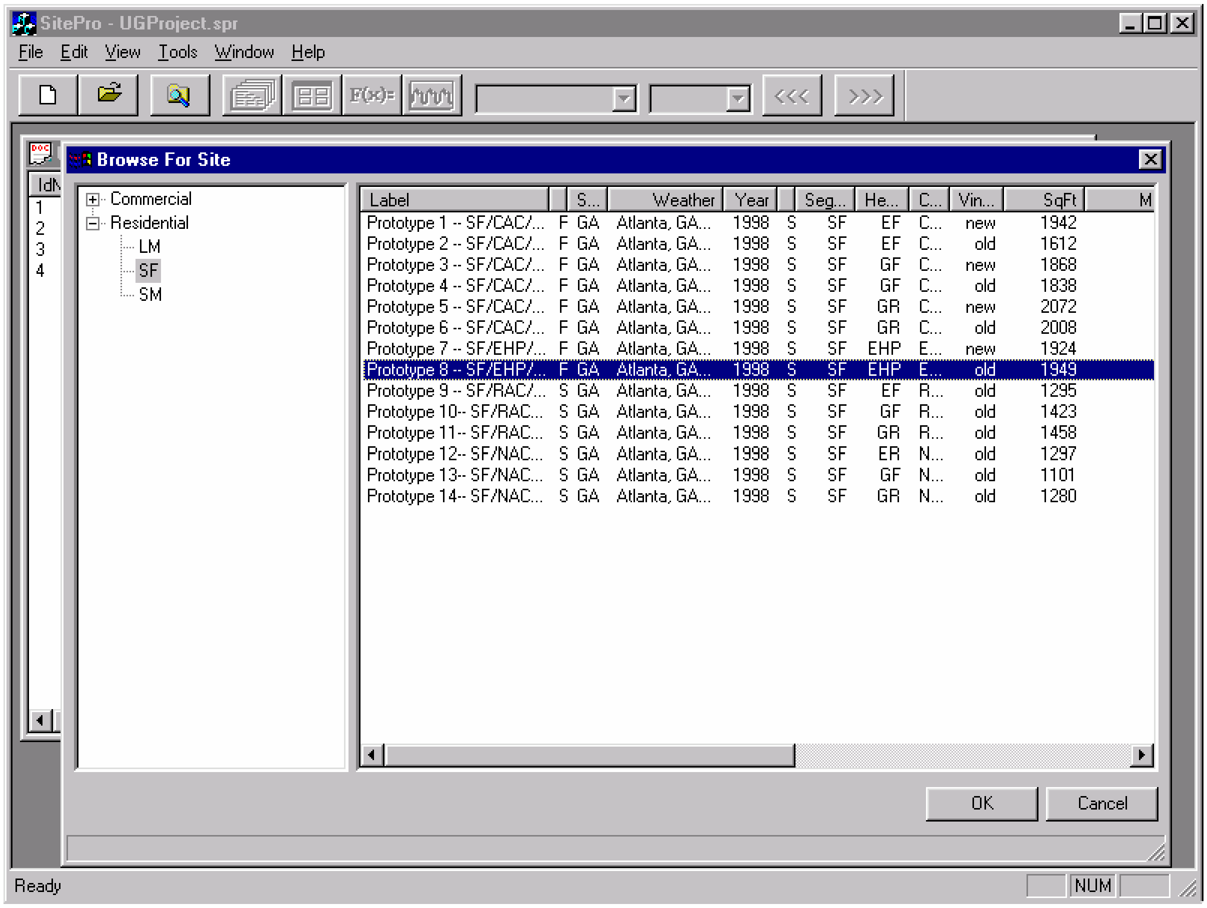
Project Files and Library Files. The residential and commercial prototype libraries have significantly different layouts. For example, the residential database has fields for household demographics and appliance holdings, while the commercial database has fields for operating hours and commercial equipment holdings. The project files for each sector have the same layout as the corresponding prototype library. As a result, it is not possible to put a commercial site into a residential project and it is not possible to put a residential site into a commercial project.

Since BillShaper projects do not contain customer characteristics data, it is possible to mix residential and commercial sites in these projects. All that is required from the prototype libraries is hourly load data, and these tables are in the same format in both types of library files.

3.4 Browse

Once a portfolio is started, new cases are added using the Browse-for-Shape feature. This action allows the user to search prototype libraries using a standard tree control, like is used in file management systems. The control initially displays a list of libraries that are registered on the server. When the library folder is expanded, a list of segments is presented. When a segment is selected, the details box on the right hand side of the control provides a listing of all cases in the segment. An example of the file selection dialog is shown below.

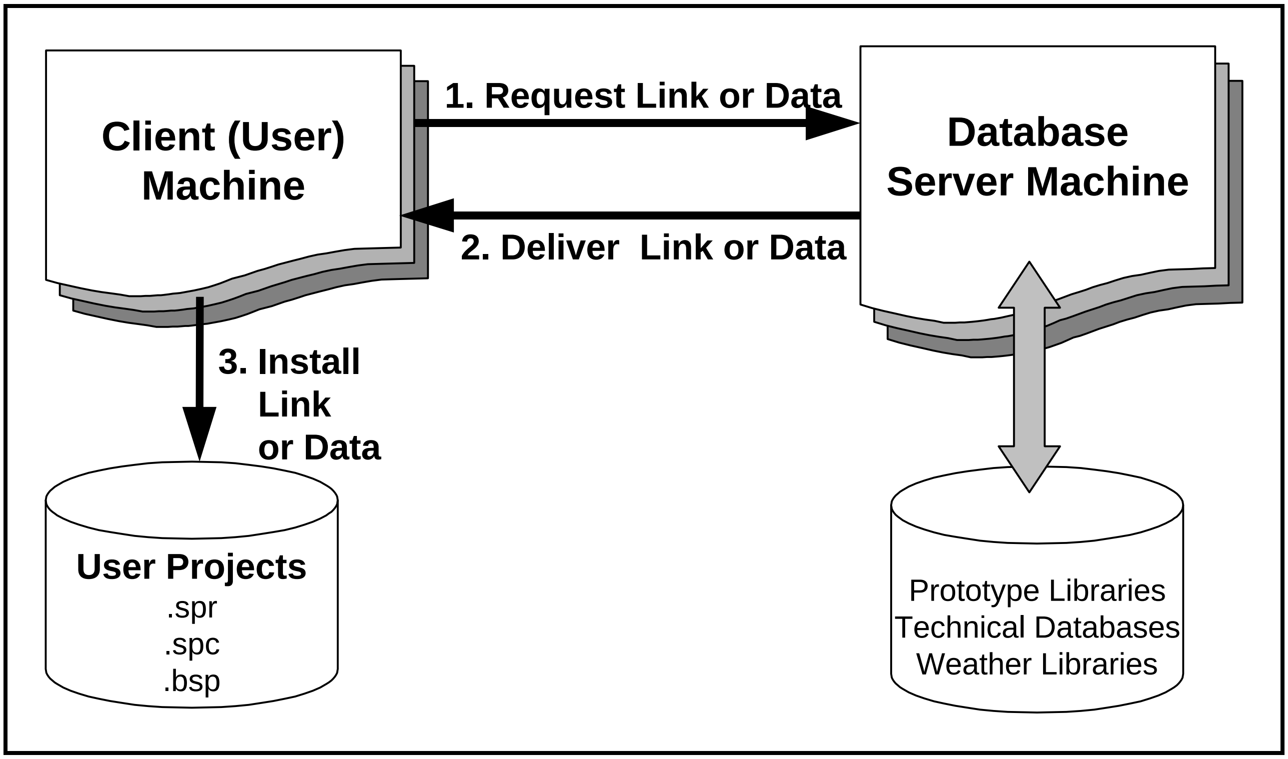
Figure 3-1: Example of Browse for Site



To fully understand the Browse action, it is useful to think of SitePro as a two-tiered system, involving a client machine and a database server machine. SitePro is written using COM (Component Object Model) technology, and there is really a third layer (the business layer), but it is not useful to visualize this layer to understand the Browse action.

When the Browse action is implemented, the client program on the user's machine connects to the server. The server provides data about the segments and cases contained in the database. The user then moves through this information to locate the desired site. When the site is selected, the client program initiates a three-step process. In step 1, the client program submits a request to the server for the data for that site. In step 2, the server processes that request and responds by delivering the requested data to the client program. Finally, the client program installs the delivered data into the project database.

Figure 3-2: Depiction of System Architecture for Browsing



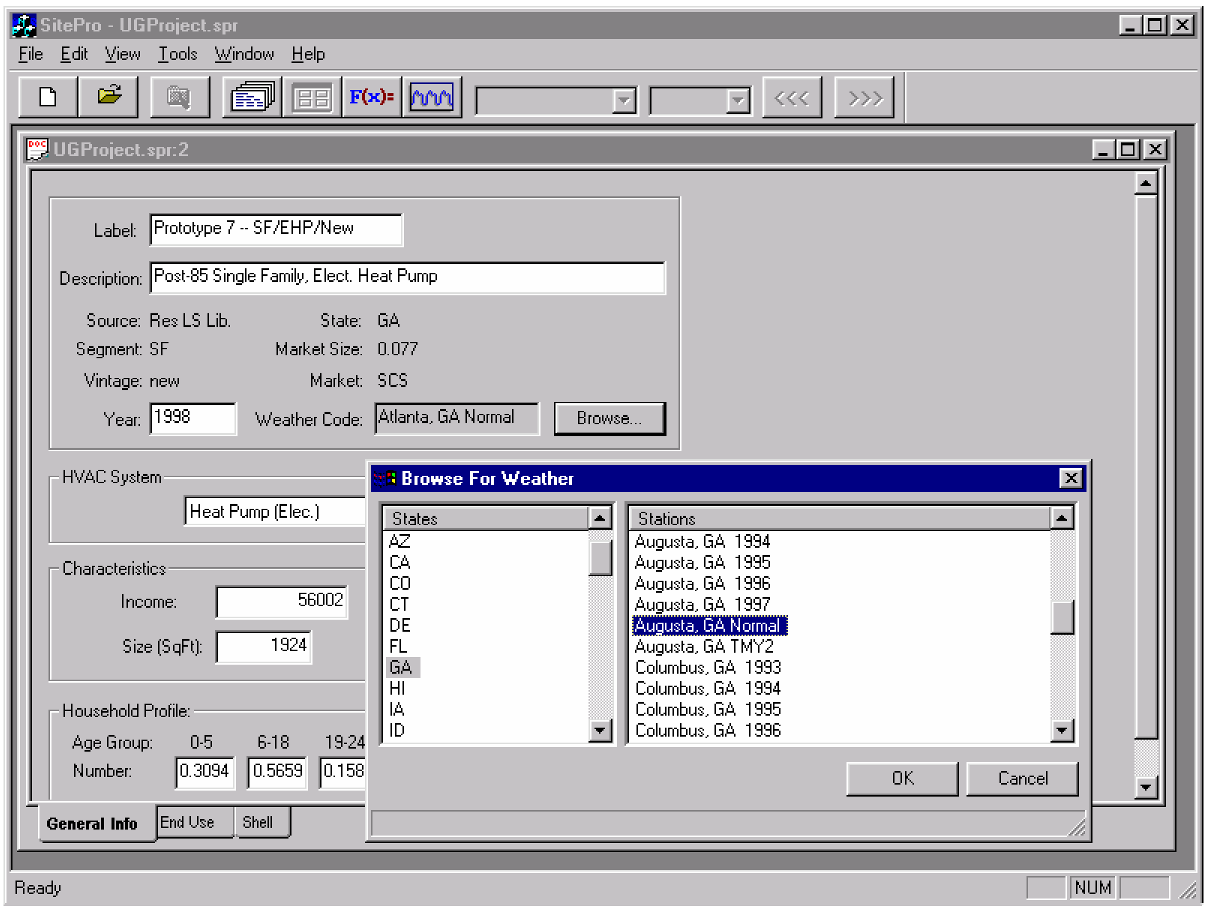
The results of a browse action depend on the module and the type of browse that is invoked. Browse actions can occur in one of three places.

Browse for Site. In the residential and commercial simulation modules, a new site is installed in a project by retrieving a site from one of the Prototype databases. In this case, the browse action brings up a list of sites for purposes of selection. As shown in Figure 3-2, the browse dialog has a tree control on the left-hand side of the screen and individual sites within a folder are listed in the right-hand side. Once a site is selected, the site characteristics data from the selected record are copied and sent to the client machine to be saved in the project file.

Browse for Weather. In both the residential and commercial simulation modules, it is possible to simulate a selected site with any of the available weather files. The weather library contains a large number of hourly weather files, including TMY files, data for actual years, and series that have been constructed to contain normal patterns, including normal seasonal high temperatures and normal seasonal low temperatures.

The weather library is organized by state. By selecting a state in the left-hand panel, the list of stations that are available appears in the right hand panel. When a specific file is selected from the list of files, the link to the appropriate file is sent to the client machine and is stored in the project file. The actual weather data are not transmitted to the client machine at any time. The link to the data provides access to the appropriate file whenever a simulation is desired.

Figure 3-3: Example of Browse for Weather Dialog



Browse for Link. In the BillShaper program, there is a portfolio of customer sites, but there are no characteristics data (other than customer bills) in the project file. However, for each site in the project file, there is a link to a load shape in one of the library databases. The link provides access to the load shape data, and these links are used whenever the execute button is pressed. The browse dialog is the same as the one shown above in Figure 3-2.

3.5 Editing Data

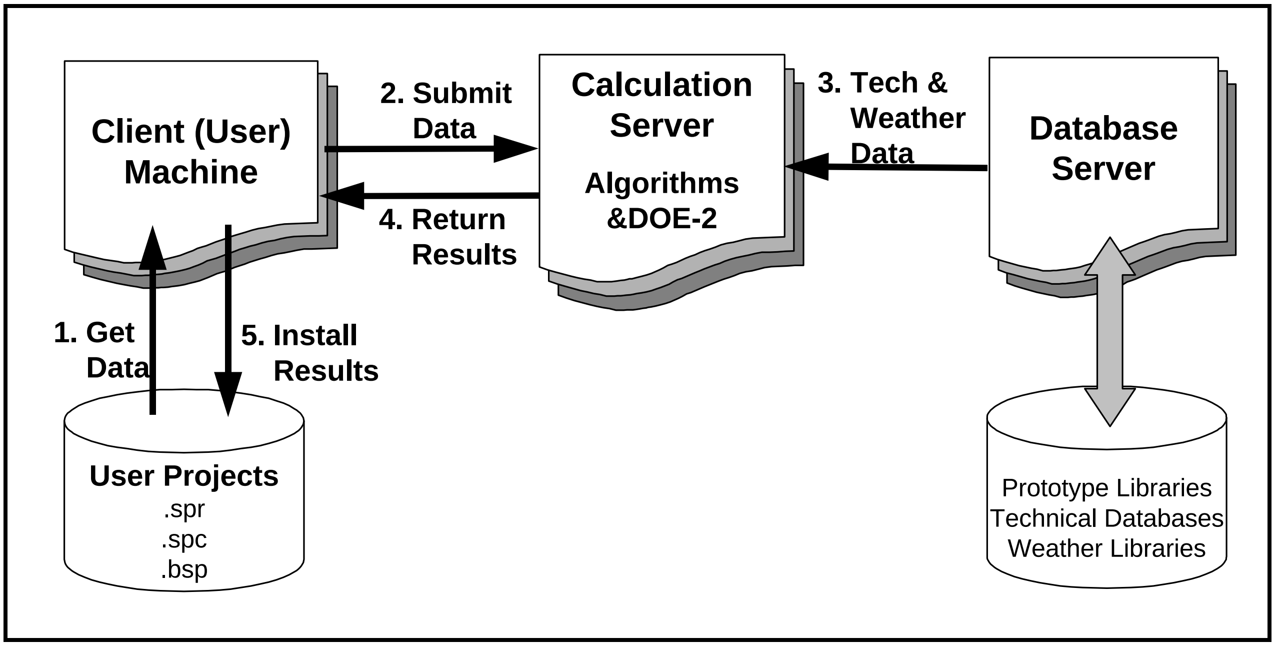
When a site is selected, the View Data button is activated. When this button is pressed, a tabbed dialog is displayed showing the data for the site. The contents of this dialog vary across the modules. For a residential project, the dialog will contain data about the household, appliances, and the home. For a commercial project, the dialog will contain data about the building and its operation. And for a BillShaper project, the dialog will contain billing data, as well as a way to link to library shapes. More details are provided in Sections 4, 5, and 6.

3.6 Executing Simulations

In the residential and commercial modules, simulations are executed for individual sites or for groups of sites that are selected for batch execution. The architecture used for executing simulations is shown below in Figure 3-4. As indicated, the following steps are executed.

1. ***Get Site Data.*** In this first step, data for the site are copied from the project file. These data include site characteristics, including information required to link to technology data and weather files that reside on the database server.
2. ***Submit Site Data to Calculation Server.*** The site data that are copied in Step 1 are sent to the calculation server. (The calculation code may be installed on the client machine or on the database server, depending on the configuration used at time of installation.). On the calculation server, a temporary directory is created and files related to the simulation are kept in this location.
3. ***Get Weather and Technical Data from Data Server.*** The simulation engine requires hourly weather data and technology data that are kept in library files on the data server. Based on information in the site data, the appropriate files and data are retrieved.
4. ***Execute Simulation and Return Results.*** Once all necessary data have been assembled, the simulation is executed. When concluded, the calculation server sends the simulation results to the client machine, and closes and deletes all temporary files and directories.
5. ***Install Results in Project.*** When the client receives the completed simulation results, they are installed in the appropriate data tables in the project file.

Figure 3-4: Depiction of Architecture for Executing Simulations



If multiple sites are selected when the Execute Simulation button is pressed, then these actions are repeated sequentially for the selected sites.

The logic for execution of a BillShaper project is slightly different. First, all sites and groups are processed, regardless of what item is selected in the interface. Second, BillShaper projects do not involve execution of DOE-2. As a result, the calculation logic is much simpler and no physical simulations are performed.

3.7 Exporting Whole Building Loads

The simulation results are stored in a set of tables in the project file. Although these files have extensions specific to each module (.spr, .spc, and .bsp), each project file is in Microsoft Access format. These files can be opened in access and any of the results can be printed, exported to text files, or saved as Excel files.

The files can also be exported from SitePro to text files in LDAW format (.lda), 102 day format (.102) or Pricem format (.pcm) This export applies to the 8,760 hourly electric loads only. To export these data:

Select the case and press the Results button on the Toolbar
Select the Daily graph
From the menu select File→Export.
Select the format from the "Save file as type" control.
Enter the file name, and Press OK.

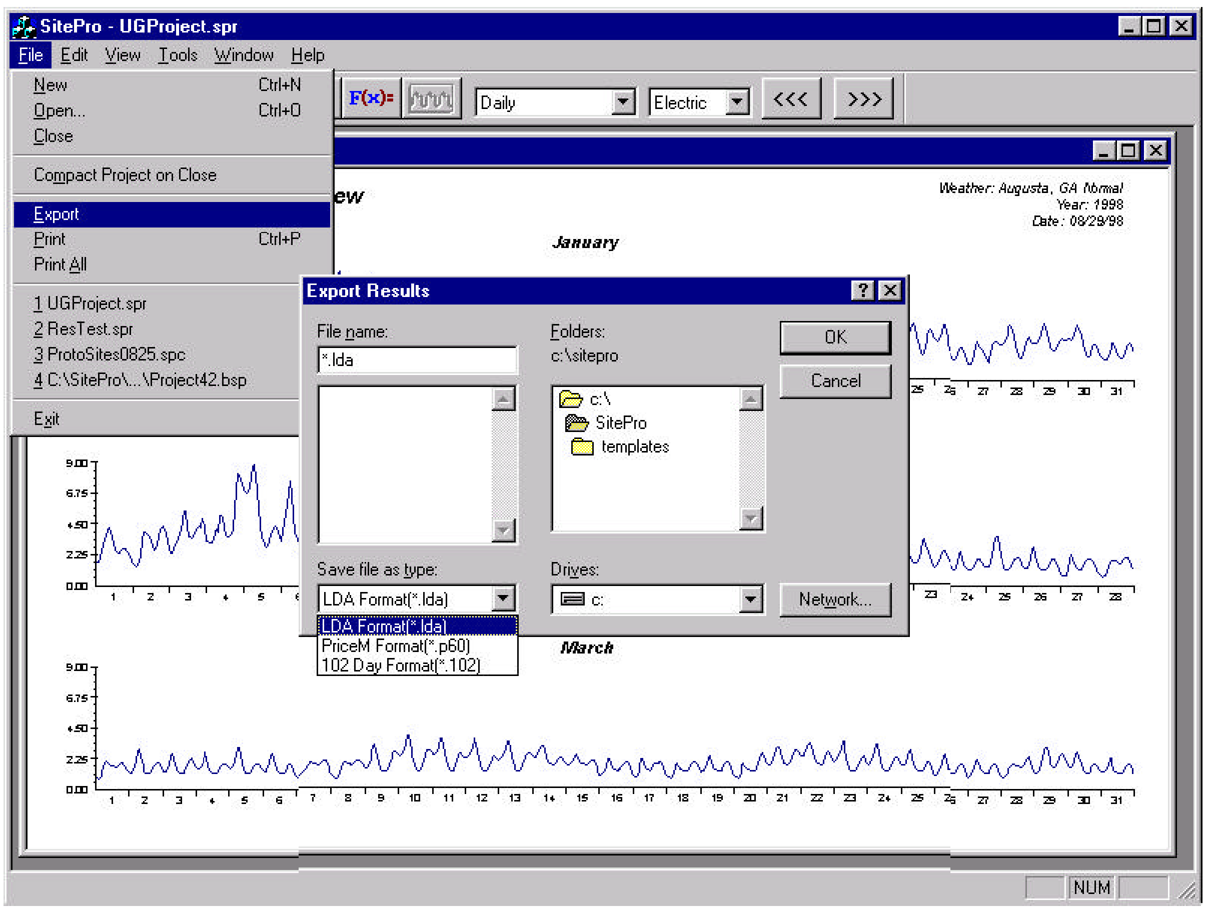
The formats are described briefly below.

- ***LDAW Format (.lda).*** This format saves an 8,760 hour load as two records per day. The first record contains data for the first 12 hours and the second record contains data for the second 12 hours.

- ***102 Day Format (.102).*** This format contains 8 records for each month, including a typical Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday, and Peak Day. The peak days are constructed from the three weekdays with the highest loads. The last 6 days are the standard holidays for utility rates, New Years, Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas.

- ***Pricem Format (.pcm).*** This format contains 30 records for each month. The first 24 records for each month contain data for the average weekday load in each hour. Holidays are excluded from the averaging process. The last 6 records for each month contain average loads for weekends and holidays in 4 hour blocks.

Figure 3-5: Exporting an 8,760 to a File in LDA Format

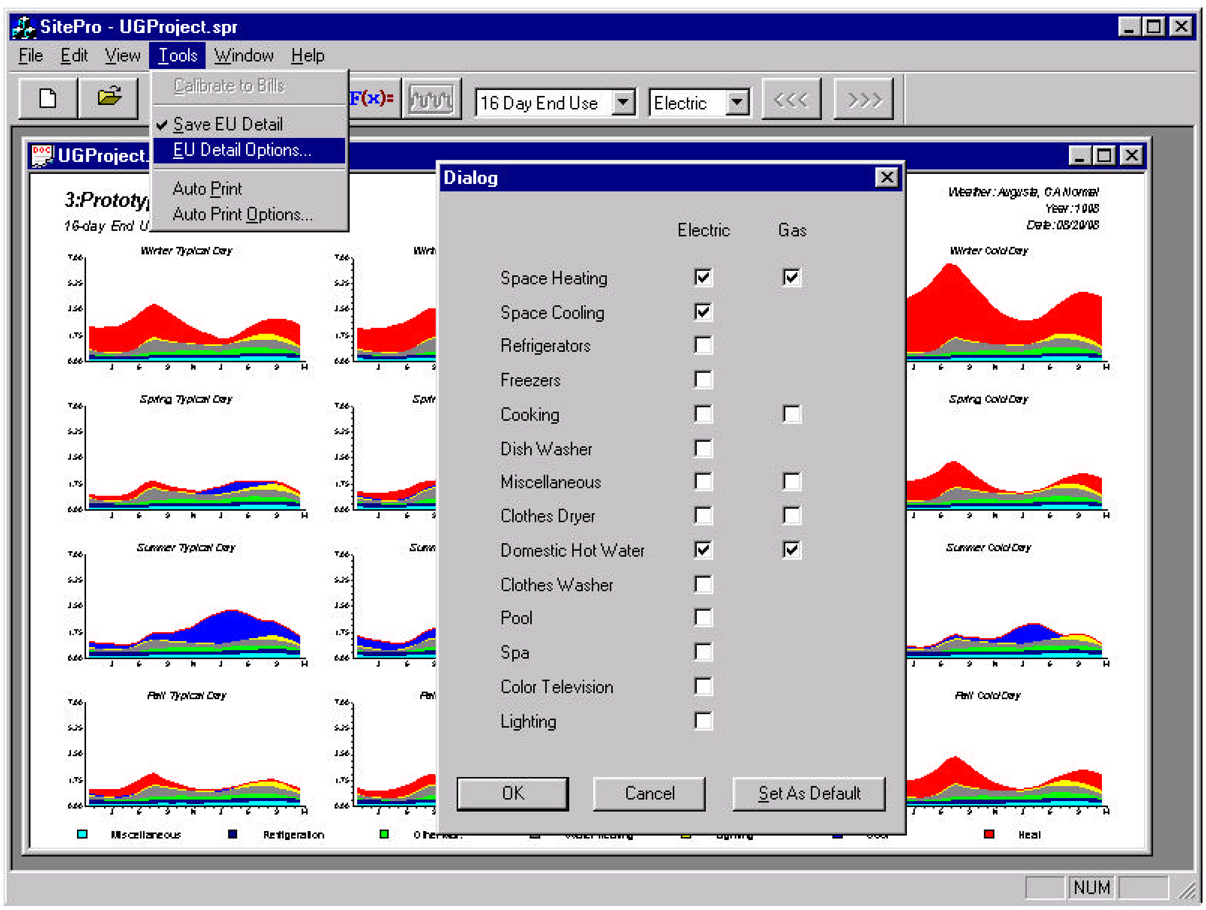


3.8 Saving End-Use Detailed Results

In addition to the whole-building results, it is possible to save 8,760 results for individual end uses. This is done by selecting Tools→Save End-Use Detail. When this option is on, all 8,760 values for the end-use loads that have been selected are appended to an Access database that has the same name as the residential or commercial project file with a .mdb extension added. The database contains one record for each day of data, and each record also identifies contains fields for the SiteID, End-Use, Fuel, and Date.

Each time a simulation is run with the save option activated, the resulting data are appended to this database. This database is created in the same directory as the project file if it does not exist at the time of the run.

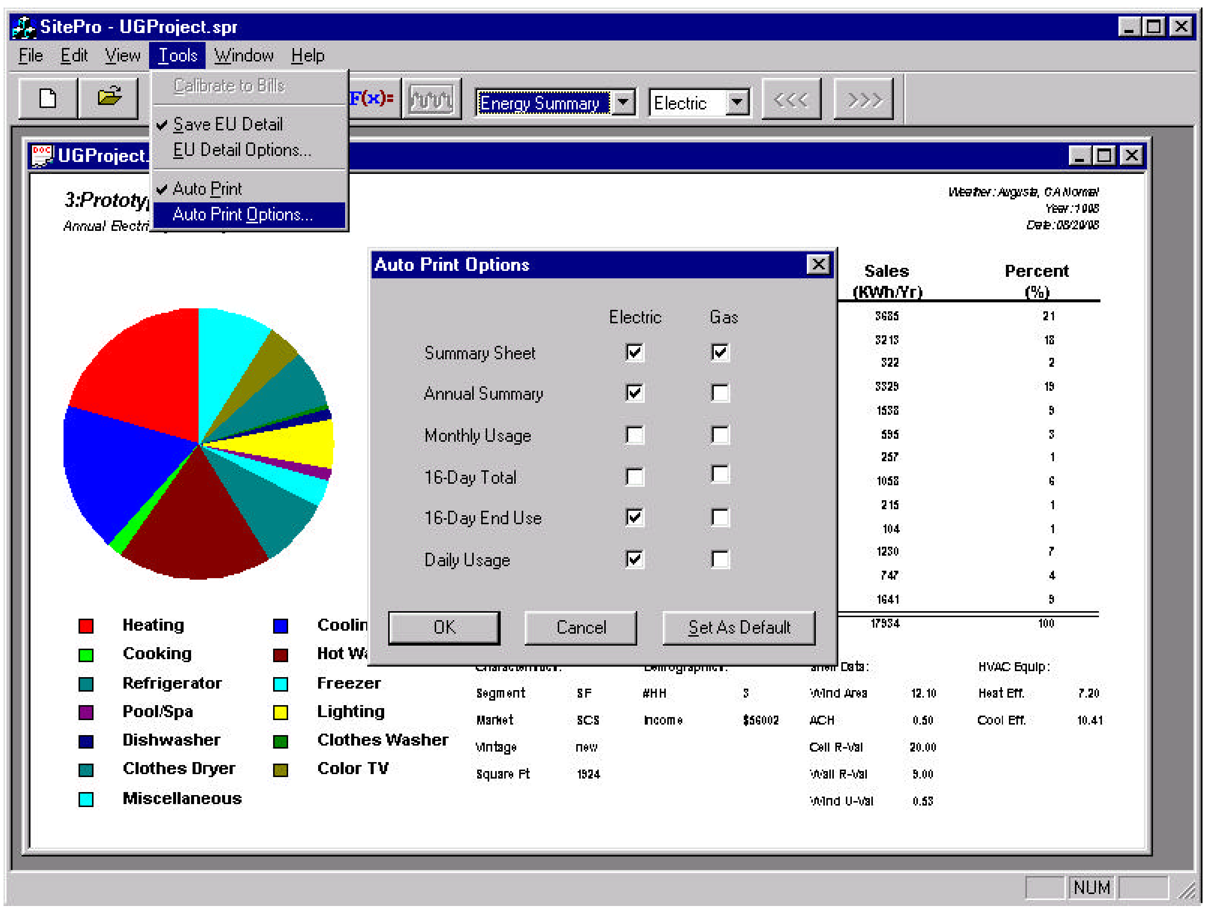
To identify the end-uses and fuels to save, select Tools→EU Detail Options. This action will bring up a dialog with a series of check boxes for electric end uses and for gas end uses. Select the desired options. Press the *Save As Default* button to make this the default selection. Press OK to install the options for the current session.



3.9 Automatically Printing Reports

In production mode, a user will sometimes want to process a batch of cases and receive printed output as a result of the batch runs. To automatically print reports when a single case or a set of cases are simulated, select Tools→AutoPrint.

To identify the specific reports that you wish to obtain, select Tools→AutoPrint Options. This will result in a dialog that provides a list of reports for each fuel. Select the desired options. Press the *Save As Default* button to make this the default selection. Press OK to install the options for the current session.



4

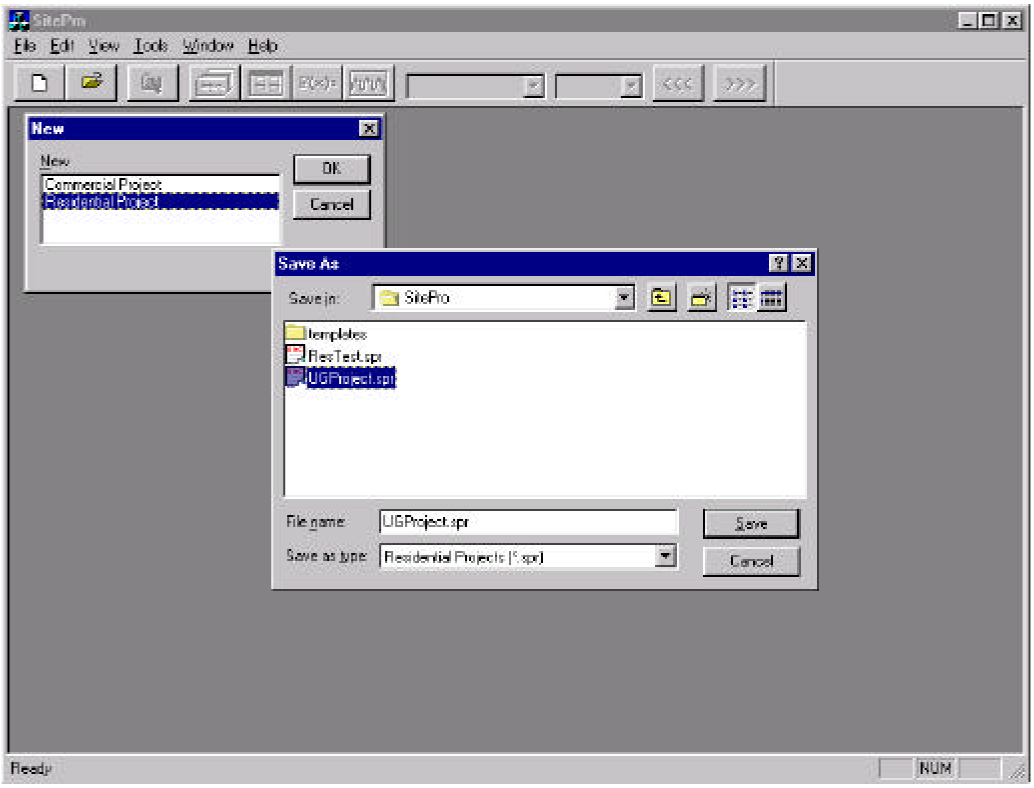
Residential Simulation Module

This section describes the steps for executing the residential simulation component of SitePro. A general discussion of features common to all modules is presented in Section 3. This section focuses on features that are specific to the residential module.

4.1 Execute SitePro

When SitePro is started, it will automatically connect to the database server and present the main program screen. Once the main program screen is shown, the user may create a new project by selecting File→New from the menu or by pressing the “New” button on the toolbar. As shown in Figure 4-1, this will bring up a selection dialog with a list of the project types. Select the Residential option. A “Save As” dialog will then be provided. Enter a directory and file name. This will result in creation of an empty project database.

Figure 4-1: Creating a New Residential Project

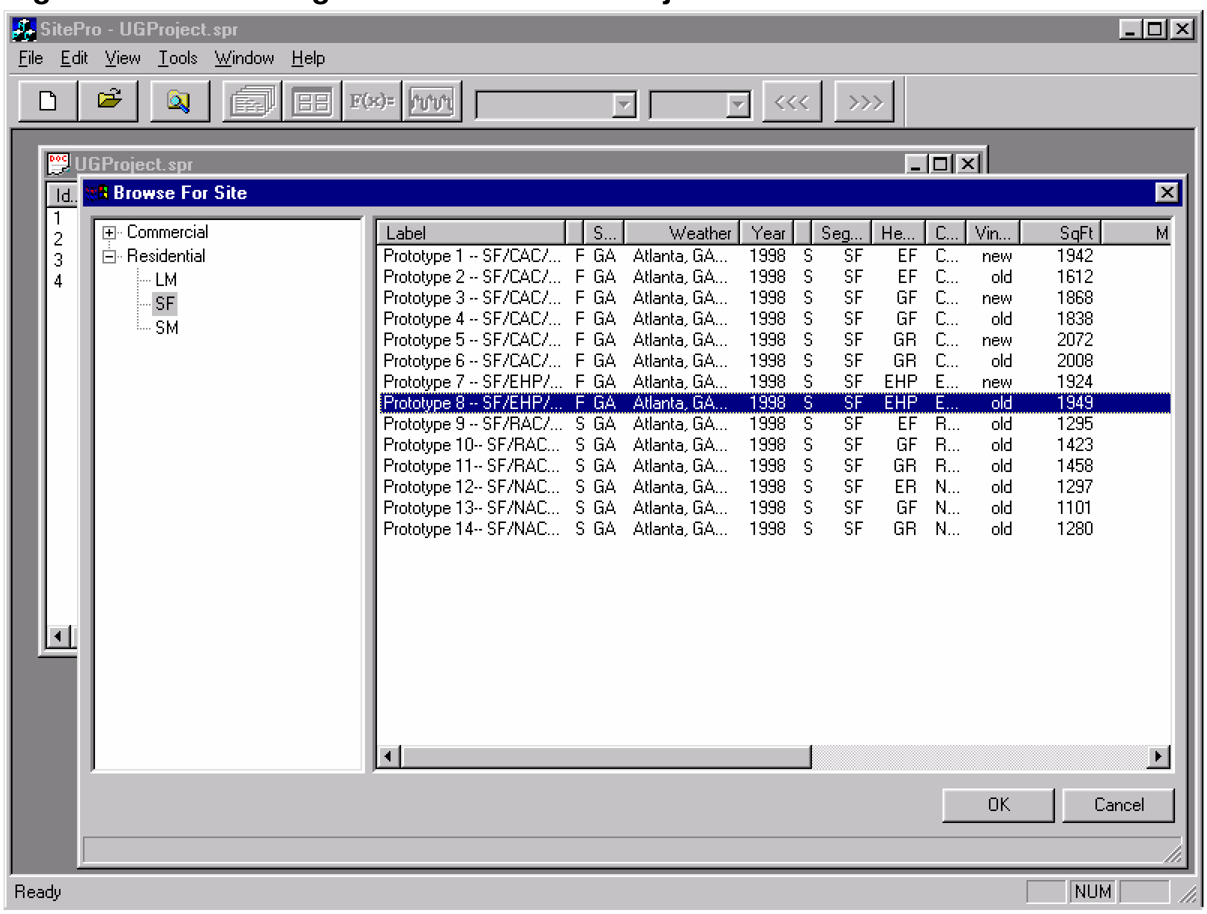


To open an existing project, select File→Open from the menu or press the "Open" button on the SitePro toolbar. This will result in a standard file open dialog. To select a residential file, search for files with a .spr extension.

4.2 Adding Sites to the Project File

When a new project is started, it is empty, and there are no sites in the project database. An existing project typically will contain some number of sites. In either case, the Browse feature is used to add sites from the prototype library on the database server. For residential projects, the browsing action, which is illustrated in Figure 4-2, proceeds as follows.

Figure 4-2: Browsing to Add a Site to a Project



Select a Prototype Library. From the project view, click on the "Browse" button. A tree control will be provided indicating all prototype libraries that are registered and available to the user. Select the residential library of interest by double clicking on the library name or by expanding the segment list for that library.

Select a Segment. After selecting a library, a list of segments in the library will appear in the right hand panel or below the library label, as shown in Figure 4-2. The aspect of the database that is used for segmentation is configurable by the system administrator. In the example shown, segmentation is by state, and the filter is set to show all sites whose state code is GA.

Select a Site. By selecting a segment, a filtered list of sites in the prototype library is presented. Select a prototype site by clicking on the site and pressing "OK." To make the selection process easier, key prototype characteristics are provided. For the residential segment these characteristics include the following:

- Site name or label
- Site weather and weather year
- Housing Segment (single family, small multi-family, or large multi-family)
- Heating Equipment and Cooling Equipment
- Housing Vintage (new or old)
- Housing Size (square feet)

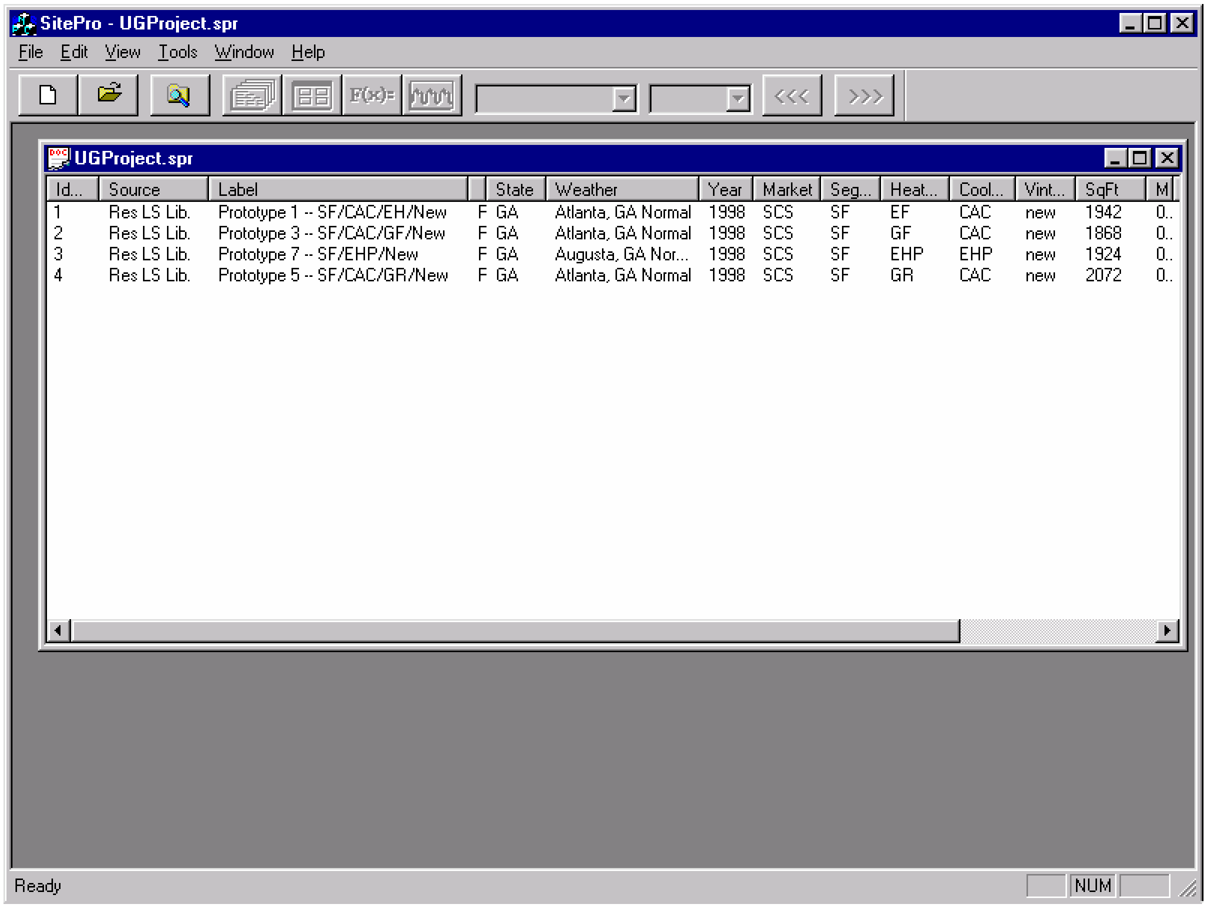
It is possible to sort the filtered list of sites by clicking on any of the column headers. A single click sorts in ascending order. A second click sorts in descending order. Column widths can be adjusted by clicking on the sides of the column headings and dragging them.

Once a site is selected, SitePro will return the user to the Project View, which shows the list of sites that have been included in the project portfolio. These sites are included in the project database, and each site is marked as one of the following:

- Needs Simulation
- Up To Date

This field comes from the prototype libraries as Up To Date, indicating that the load shapes in that are copied to the project file are consistent with the characteristics data that are copied to the project file. Upon any change to the site data, the copy in the project file is market as Needs Simulation. An example of a project file in Project View is provided in Figure 4-3.

Figure 4-3: Example of Project View



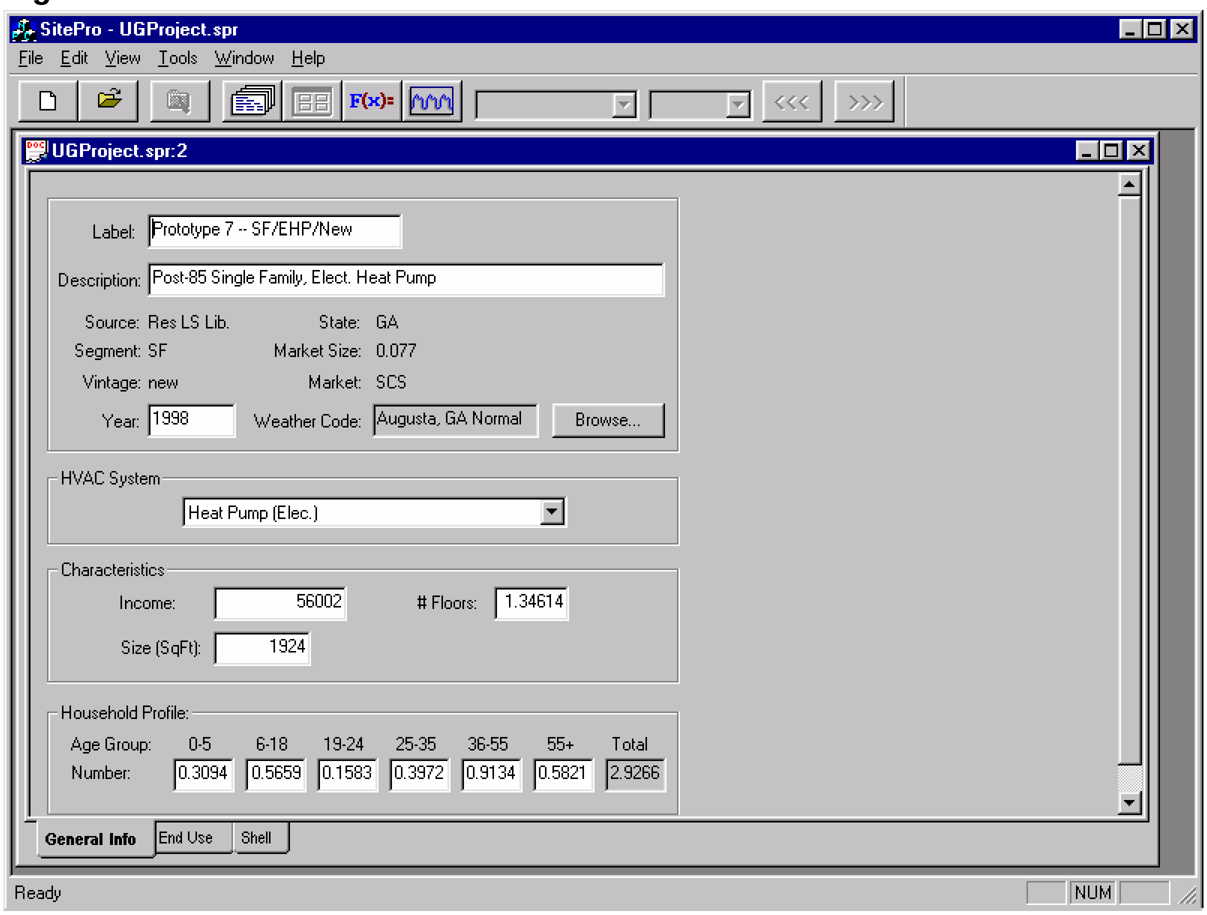
4.3 Review, Modify, and Save Site Characteristics

Once a site is included in the project, its characteristics can be viewed or modified. To view or modify the characteristics, highlight the site, and press the "View Data" button on the SitePro toolbar, or double click on the site in the project portfolio. Either action results in creation of a tabbed dialog containing four tabs. Examples of these tabs are shown in Figure 4-4 through Figure 4-6. Changes are saved when the user closes the window or executes a simulation. The characteristics window may be closed using the "X" in the upper right hand corner of the window.

General Information Tab. The general information tab (Figure 4-4) presents the following information for the selected site. While the site may have default information based on the specifications in the prototype library, the user may revise the majority of the key characteristics as needed to represent a modified site.

- ***Label and Description*** are the name and description fields for the site.
- ***Year*** is the calendar year that will be used in the simulation. The hourly simulation results will be placed on a calendar that represents the timing of weekends and holidays for that site.
- ***Weather*** is the weather file that is used in the simulation. The weather station can be changed by using the browse feature. This accesses the database server to provide a list of available files for each state.
- ***HVAC System*** identifies the primary heating and ventilation system at the site. A total of 34 HVAC system configurations are available.
- ***Characteristics*** include economic and demographic characteristics such as house size (square feet), number of floors, and the annual gross income of the household.
- ***Household Profile*** contains the number of people in the household of various age categories. Household profile information is used by SitePro to estimate energy use and to assign a lifestyle segment.

Figure 4-4: View Data – General Info



End-Use Tab. The end use tab shown in Figure 4-5, presents specific technology information for a selected set of appliances (note that the HVAC system selection is made on the General Info tab. The user specifies the share of specific appliances and an optional multiplier.

- ***Modeled UEC.*** For HVAC uses, the first column presents the UEC values that are developed from conditional demand equations. Modeled UECs for the HVAC system are not directly utilized in the construction of energy load shapes. They are provided as reference values.
- ***DOE-2 UEC*** represents UEC values calculated by the DOE-2 building simulation model. DOE-2 UECs are directly utilized in the construction of energy load shapes.
- ***DOE-2 Multiplier*** allows for a manual adjustment of the DOE-2 simulated UEC for the HVAC systems. Typically users will impose multipliers for UECs simulated by the DOE-2 model since household behavior (i.e., vacations, business travel, and etc.) results in different energy use outcomes than those derived from engineering based programs. The DOE-2 multiplier allows SitePro users to calibrate building simulation results (DOE-2 model results) to actual usage and then evaluate the impact of changing house size, thermal shell characteristics, and equipment characteristics, given these calibration multipliers.
- ***Share.*** The share column for non-HVAC equipment represents (1) the number of appliances in a specific household, or (2) the percentage mix of different appliances types if a diversified or average profile is used.
- ***Modeled UEC*** for non-HVAC appliances appears in the second column. Again, this value refers to unit energy consumption or the amount of energy that a specific appliance uses in one year, and the values are computed from conditional demand equations. Electric UECs are entered in kWh, and natural gas UECs are entered in kBtu.
- ***Final UEC*** shows the final UEC value. For HVAC uses, this is the DOE-2 value multiplied by the DOE-2 multiplier. For non-HVAC uses, this is the UEC value multiplied by the UEC multiplier.

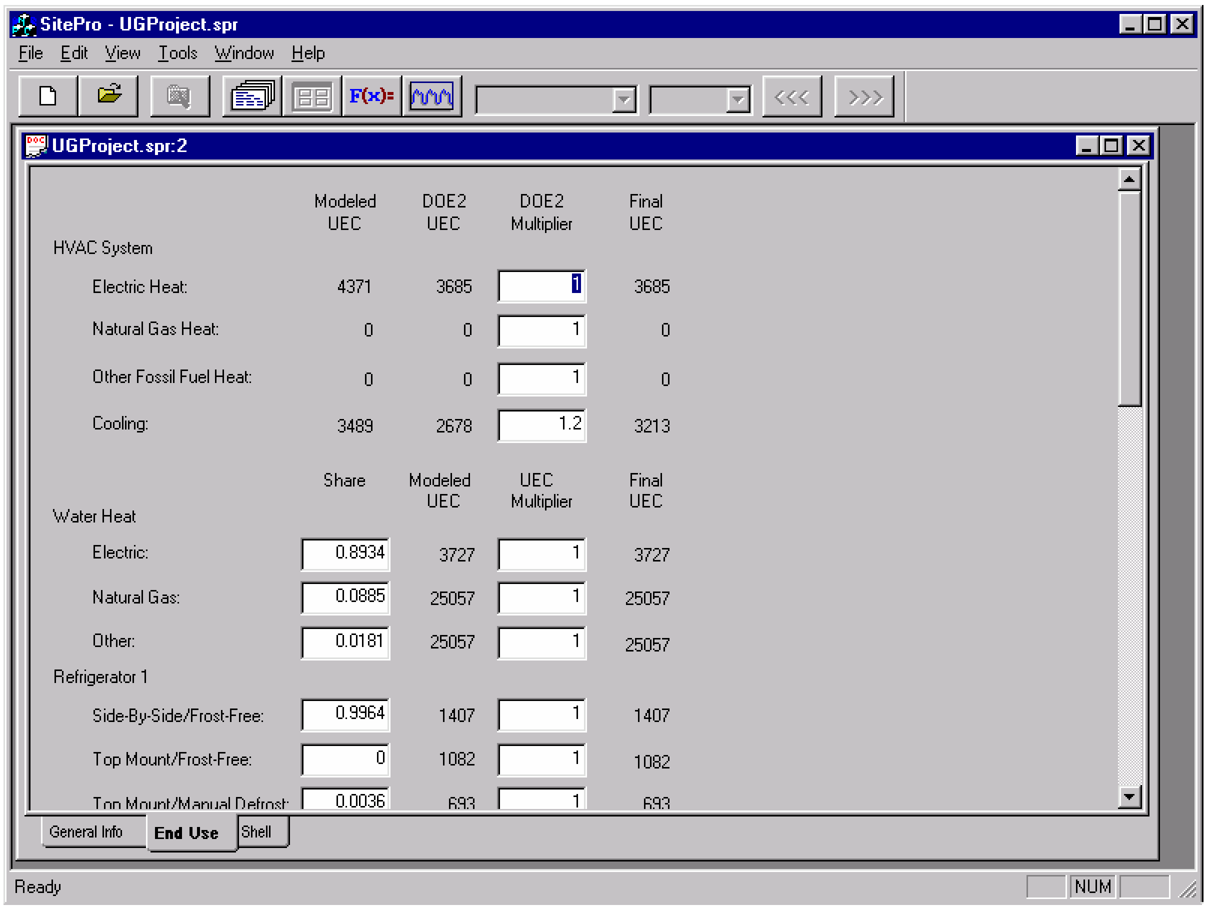
The following appliances are included in the end use tab:

- HVAC system (heating and cooling, as well as electric and fossil fuels)
- Water Heating by fuel
- Refrigerator by type of unit
- Freezer by type of unit
- Clothes Washer and Clothes Dryer by fuel
- Cooking Equipment by fuel

- Miscellaneous, including dishwasher, microwave, TV, pool, spa, and other
- Lighting.

When appropriate, SitePro provides entries for electric, natural gas, and an "other" category to cover fossil fuels such as fuel oil and propane.

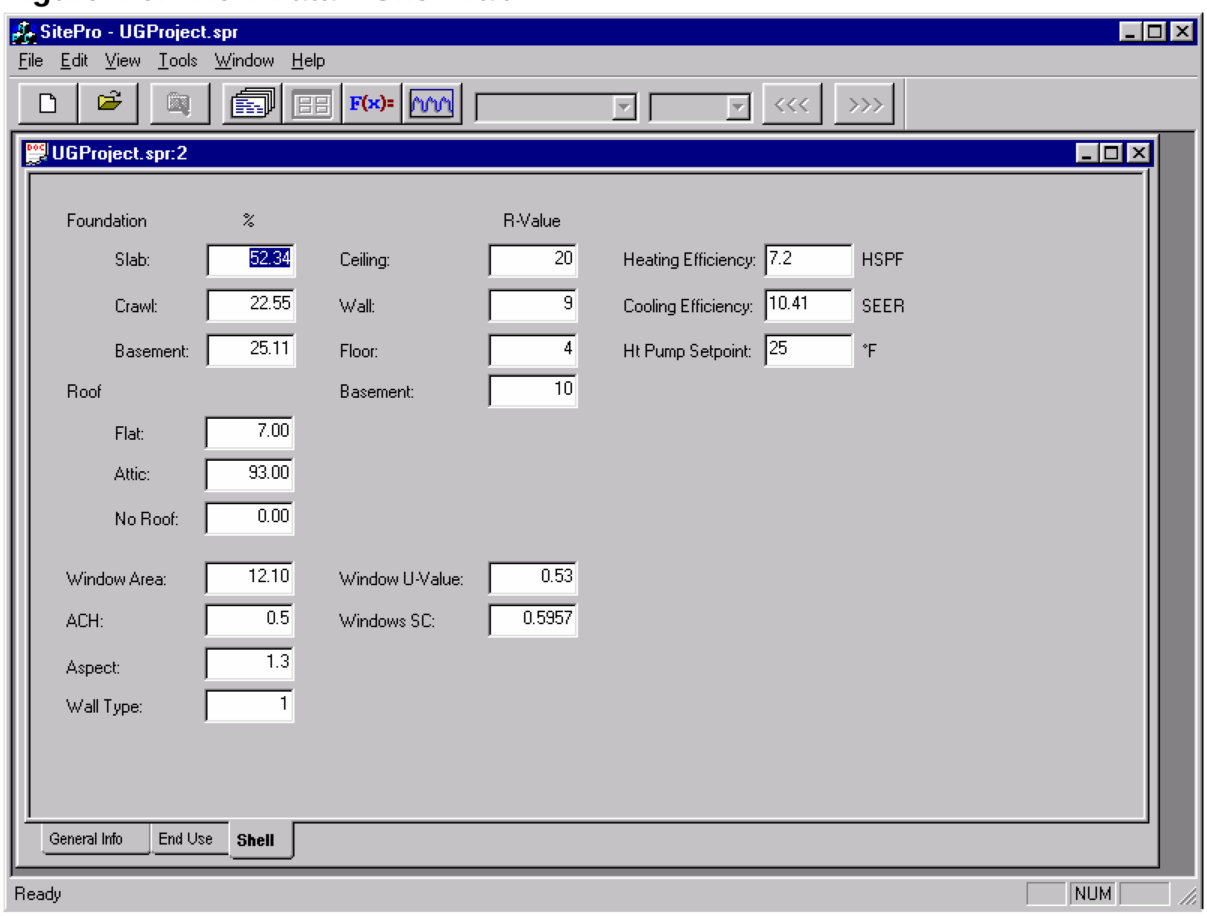
Figure 4-5: View Data – End-Use Tab



Shell Tab. The shell tab shown in Figure 4-6. It allows the user to view and edit thermal characteristics of structure as well as HVAC system efficiency. Foundation and roof characteristics are expressed as percentages of the total. For a specific site, these would be 100% for one characteristic and 0% for the others. For a mixed prototype, percentages represent the mix in a segment. Window area is expressed as the ratio of total square footage of window area to total square footage of floor area. Insulation levels are specified as R-values. The other unique features are defined below:

- ACH: Air changes per hour (normally between 1.5 and .3)
- Aspect: Ratio of house width to length.
- Wall Type: (1) is a frame cavity and (2) is masonry
- Window U-Value: Average U-value (inverse R-values) for all windows
- Window SC: Average shading coefficient (typically between 1.0 and 0.4)
- Heating Efficiency: An efficiency measure that is specific to the equipment type – HSPF for heat pumps and AFUE for fossil fuel furnaces)
- Cooling Efficiency: (expressed as either EER or SEER)

Figure 4-6: View Data – Shell Tab



4.4 Execute Energy Simulation

Once the site data in a project portfolio have been obtained and edited, the user may execute the energy simulation step of SitePro. The simulation may be executed from the project view or from the data view for a site. From the project view, highlight the desired site in the project and select the "Simulate" button. After the simulation is complete, results may be viewed by pressing the "Results" button. To execute a simulation from the data view, simply press the "Simulate" button and when the simulation ends, the results will appear on the screen.

From the project view, multiple sites may be simulated in a batch mode process. This is done by selecting multiple sites using the Shift key to select multiple sites, followed by pressing the "Simulate" button.

Upon execution, SitePro performs a full hourly energy simulation using DOE-2 and proprietary non-HVAC algorithms. The basic simulation logic is summarized below.

- SitePro estimates UECs for all equipment and appliances based on conditional demand equations embedded in a VBScript file. This file can be edited by the system administrator to change the calculation logic.
- Non-HVAC hourly load shapes are selected from a database based on a lifestyle segment designation. These shapes are multiplied by the annual UEC values to develop hourly load estimates.
- The prototype library provides all the data required to simulate HVAC uses in DOE-2. Selected information may be modified by the user as described in Step 3 above.
- Weather data, as well as internal heat gains, are required by DOE-2. SitePro automatically calculates internal gains based on the non-HVAC appliance and energy-use profile of the specific site.
- The simulation delivers load shapes for 8,760 hours for each end use.

4.5 Review and Print Results

To view results for a site in a project, highlight the site and select the "Results" button. If data have been changed since the site was last simulated, the user will be asked whether to perform a simulation. To see revised results with the edited data, select "Yes." This will result in a simulation of the site. To see the most recent simulation results that do not incorporate subsequent edits, select "No." In this case a simulation will not be executed and the old results will be displayed.

When results are viewed, the Energy Summary for Electricity appears, as shown in Figure 4-8. While viewing the results, the two pull-down menus on the Toolbar provide access to the following graphs for electricity and natural gas.

- ***Summary*** provides a condensed view of four sets of results. This one page summary provides a good overview of the end-use consumption, load shapes, and monthly usage patterns.

- ***Energy Summary*** illustrates shares, annual intensity values, peak values and, and percent of total sales for each end use and the whole site.

- ***Monthly Use*** presents monthly energy use and maximum hourly demand for each month of the year.

- ***16-Day Total*** presents whole-site load shapes for 16 day types.

- ***16-Day End Use*** presents end-use load shapes for 16 day types.

- ***8,760 Hour*** presents whole-site hourly loads, three months at a time. The double arrows allow the user to view additional months.

The full set of results are shown in Figures 4-7 through 4-20. Results for multiple sites can be viewed side-by-side by selecting each site on the project view and pressing the Results View button. Graphs for each site will be in their own window, and windows can be sized and tiled as desired.

Figure 4-7: Results View – Summary Electric

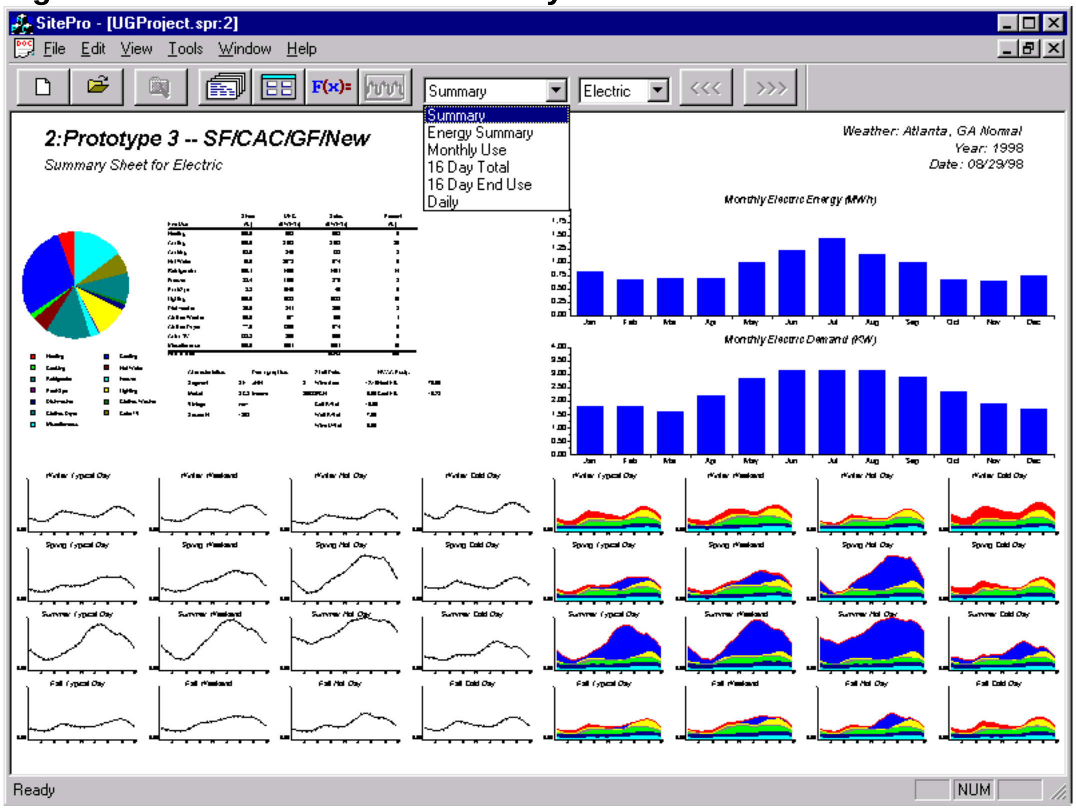


Figure 4-8: Results View – Energy Summary

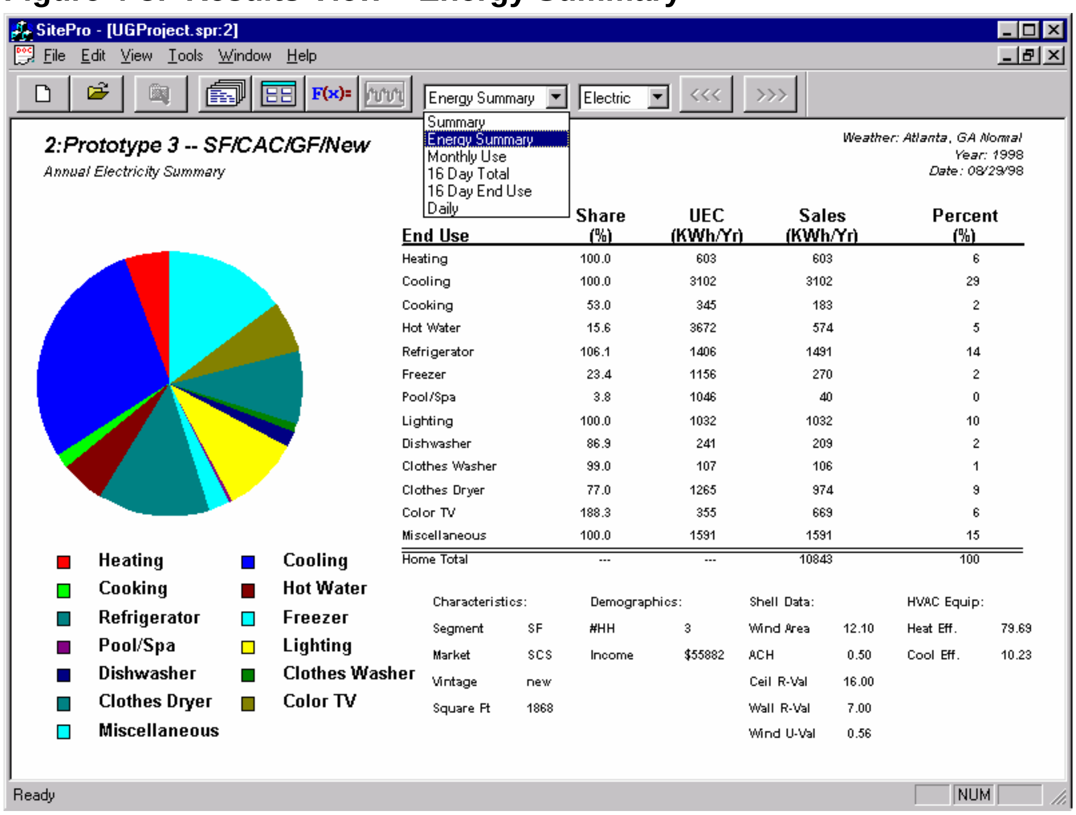


Figure 4-9: Results View – Monthly Use

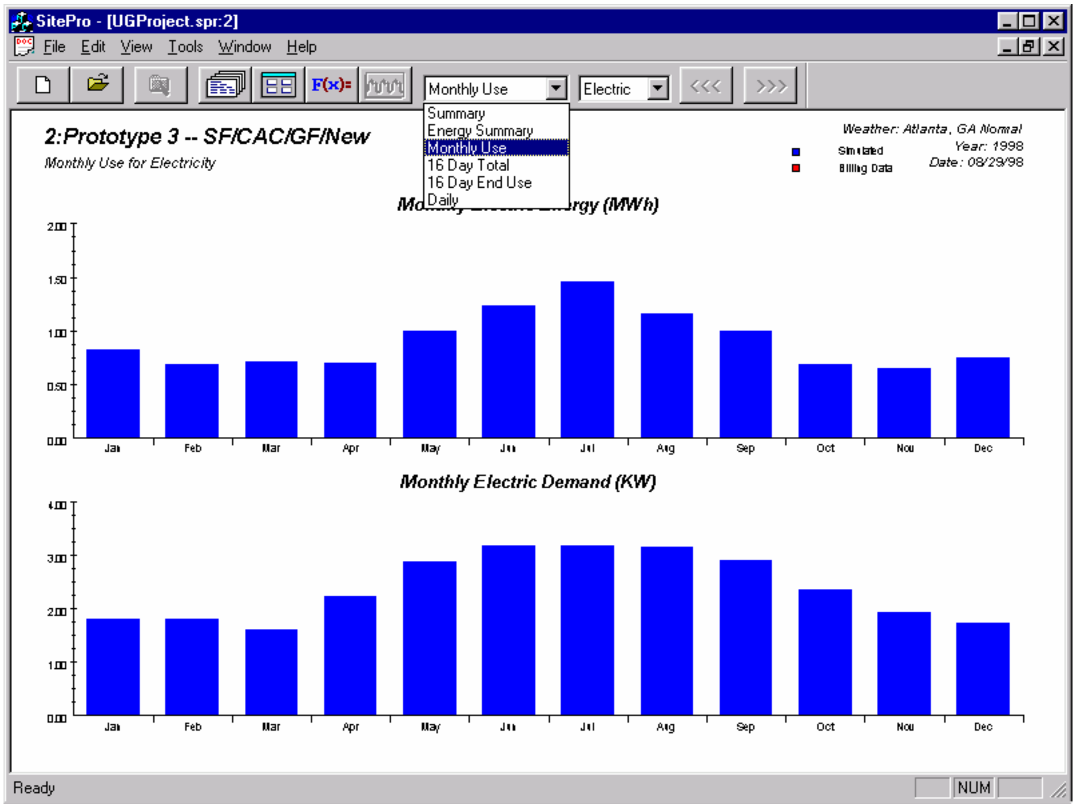


Figure 4-10: Results View – 16-Day Total

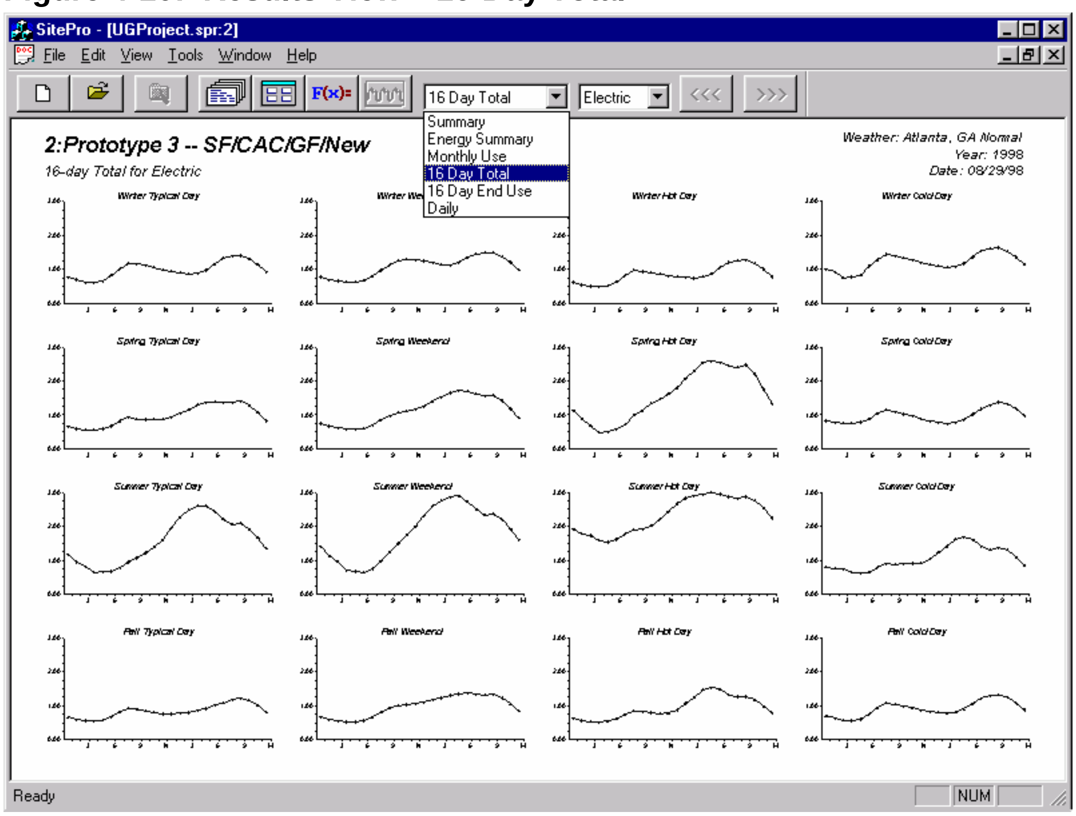


Figure 4-11: Results View – 16-Day End Use

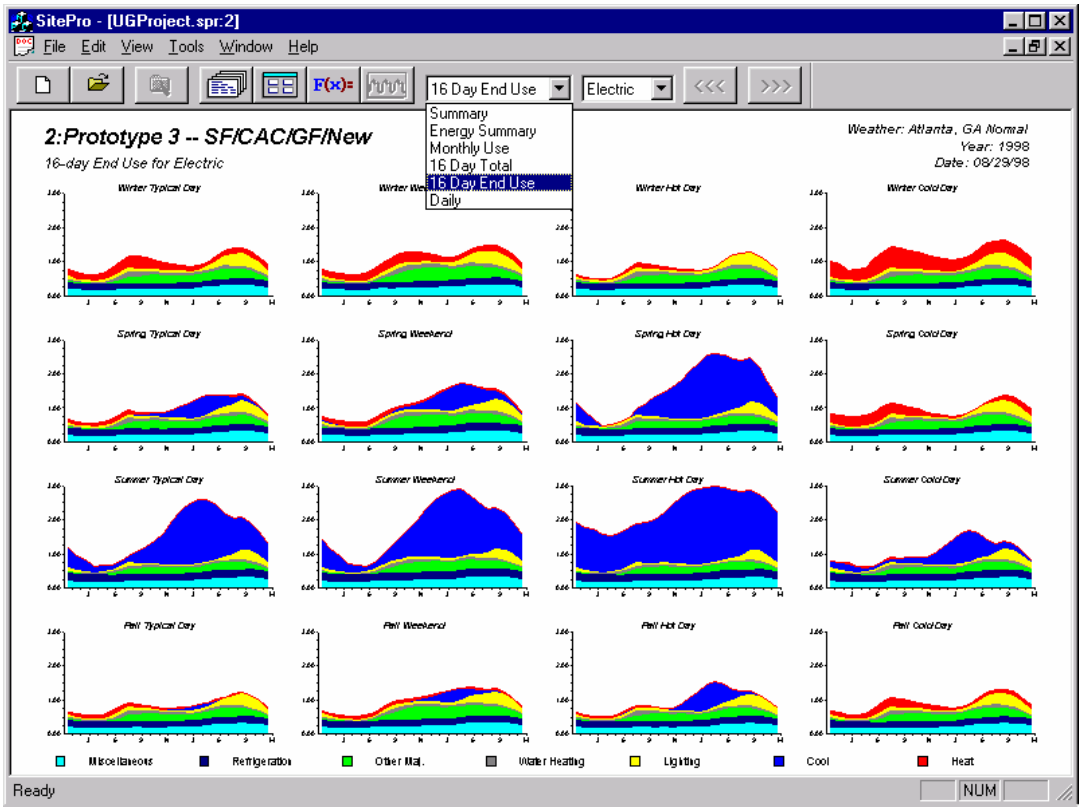


Figure 4-12: Results View Daily Shapes

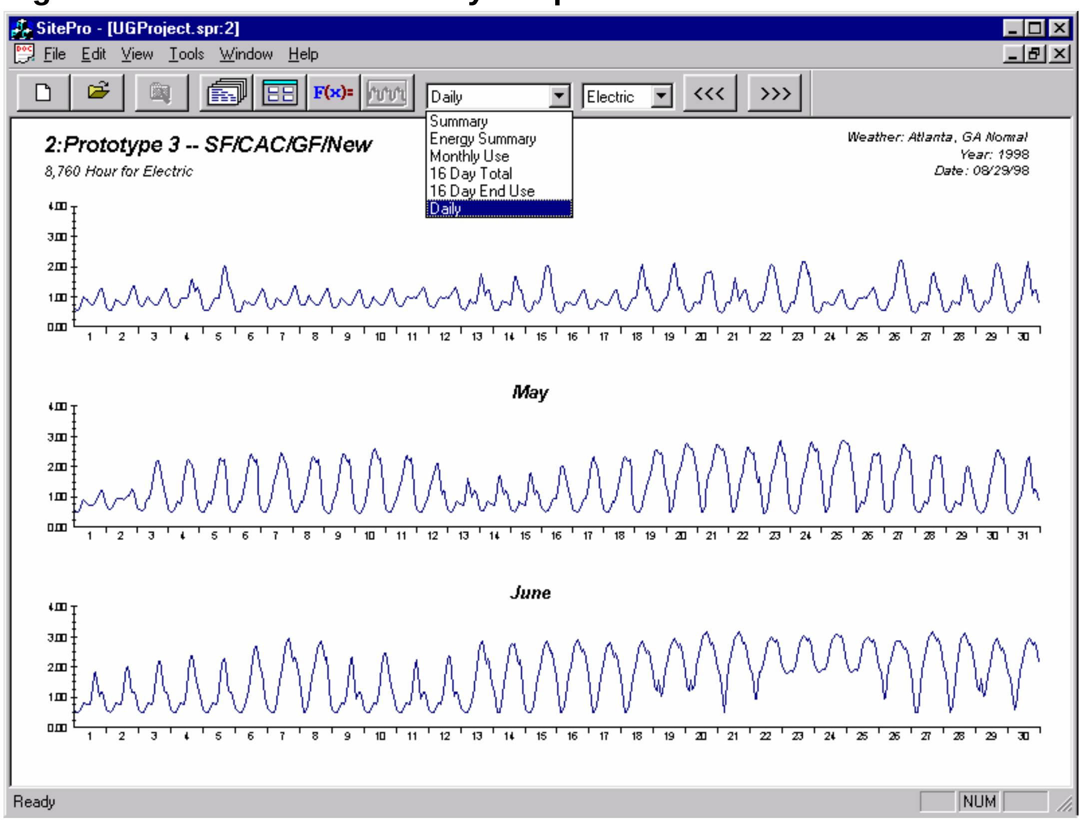


Figure 4-13: Results View – Natural Gas Summary

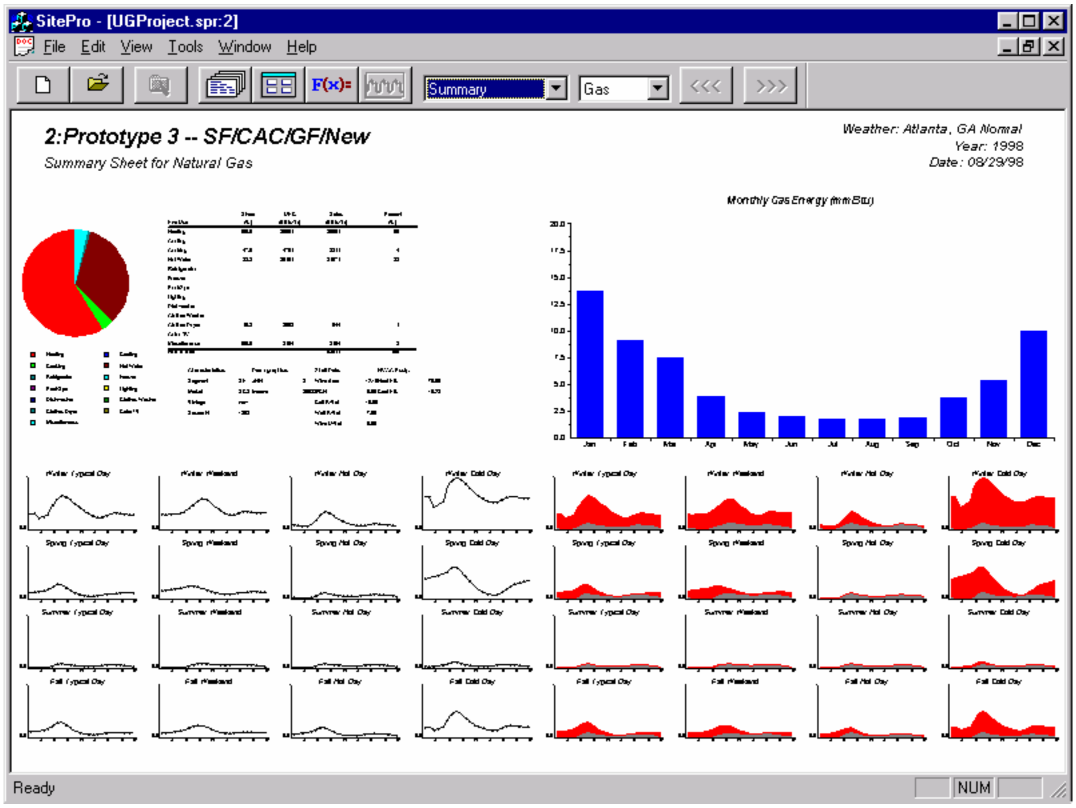


Figure 4-14: Results View – Natural Gas Energy Summary

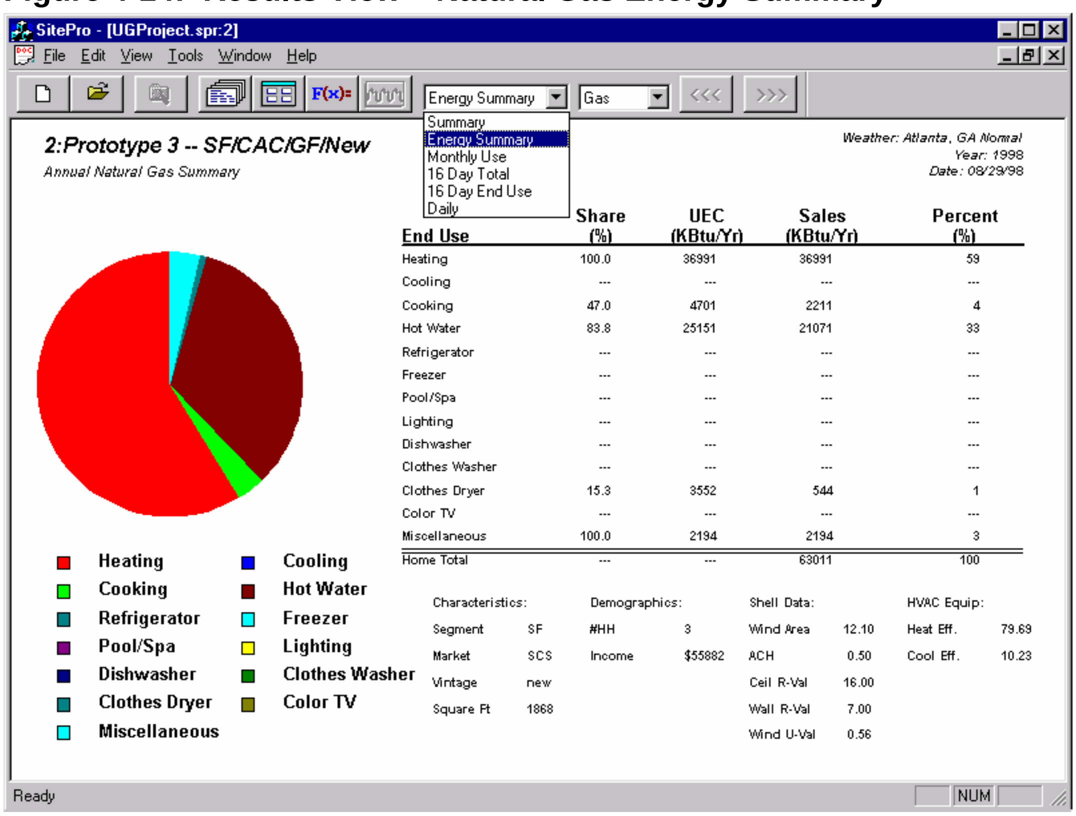


Figure 4-15: Results View – Natural Gas Monthly Use

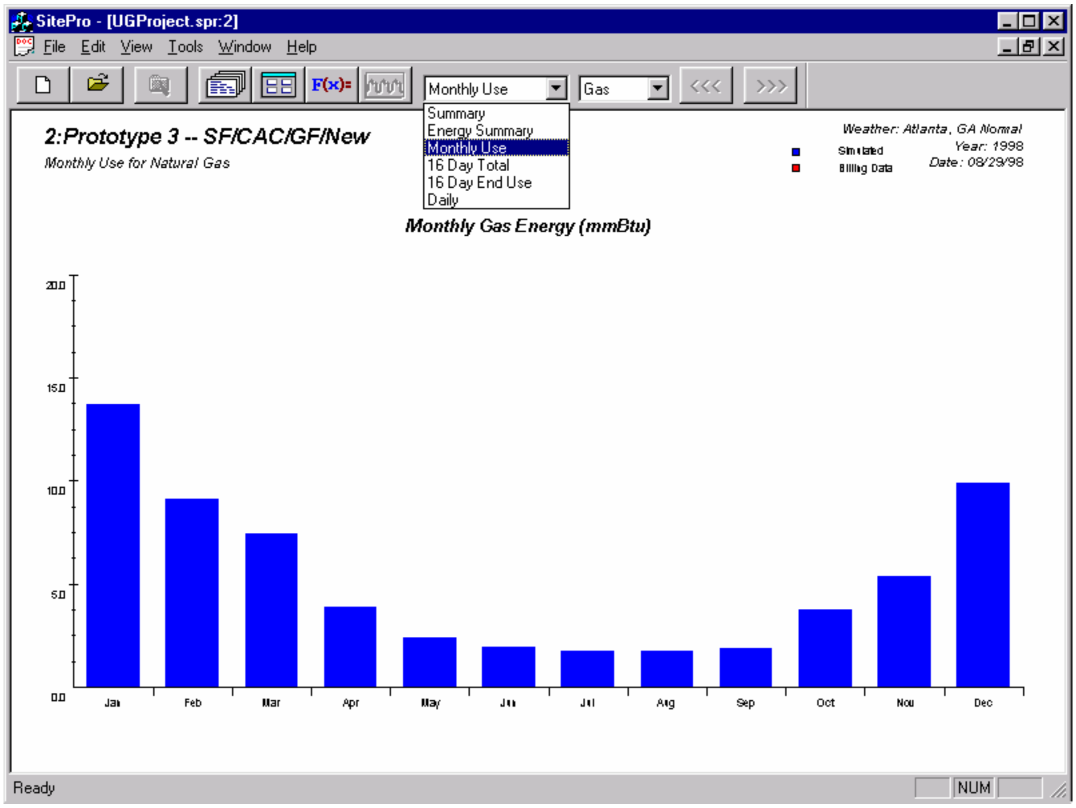


Figure 4-16: Results View – Natural Gas 16-Day Total

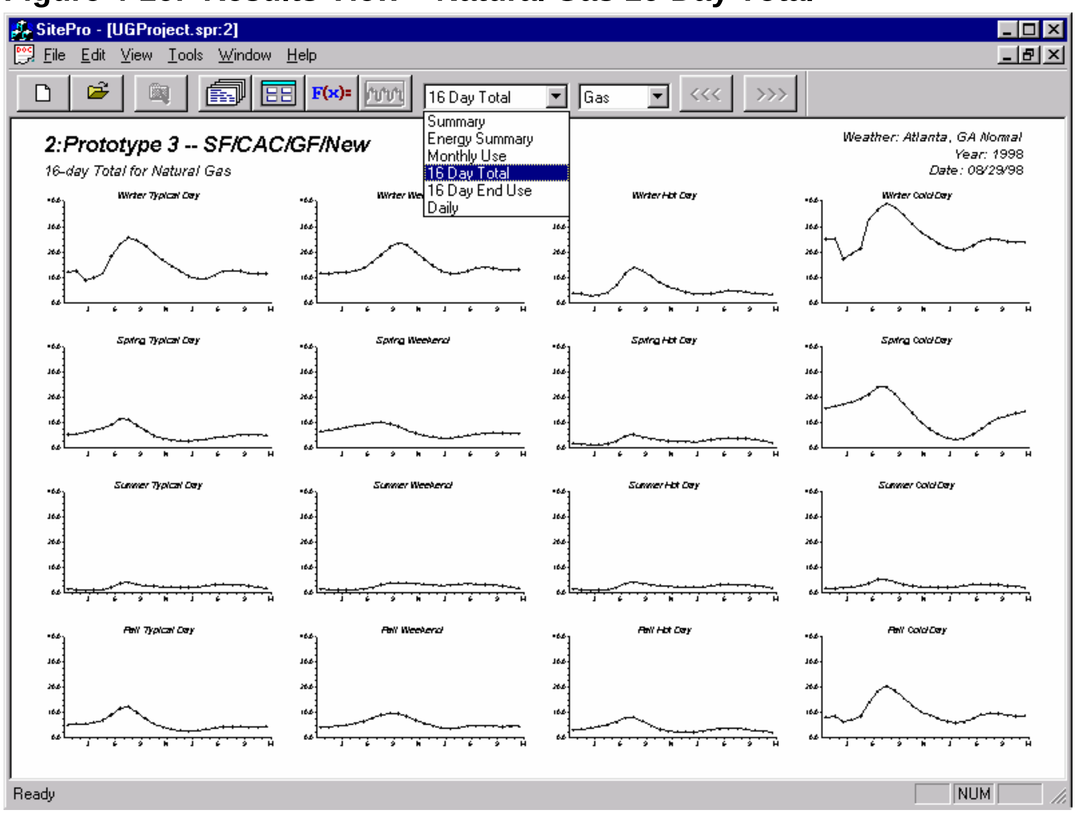


Figure 4-17: Review Results – Natural Gas 16-Day End Use

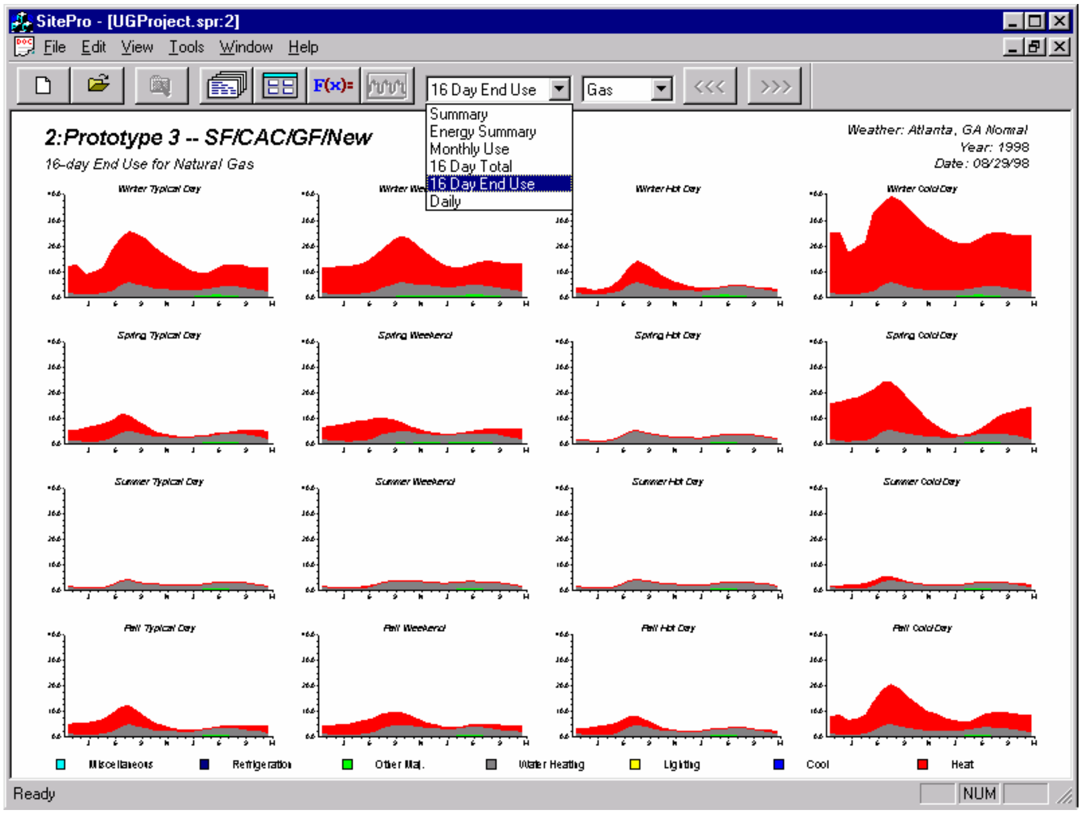
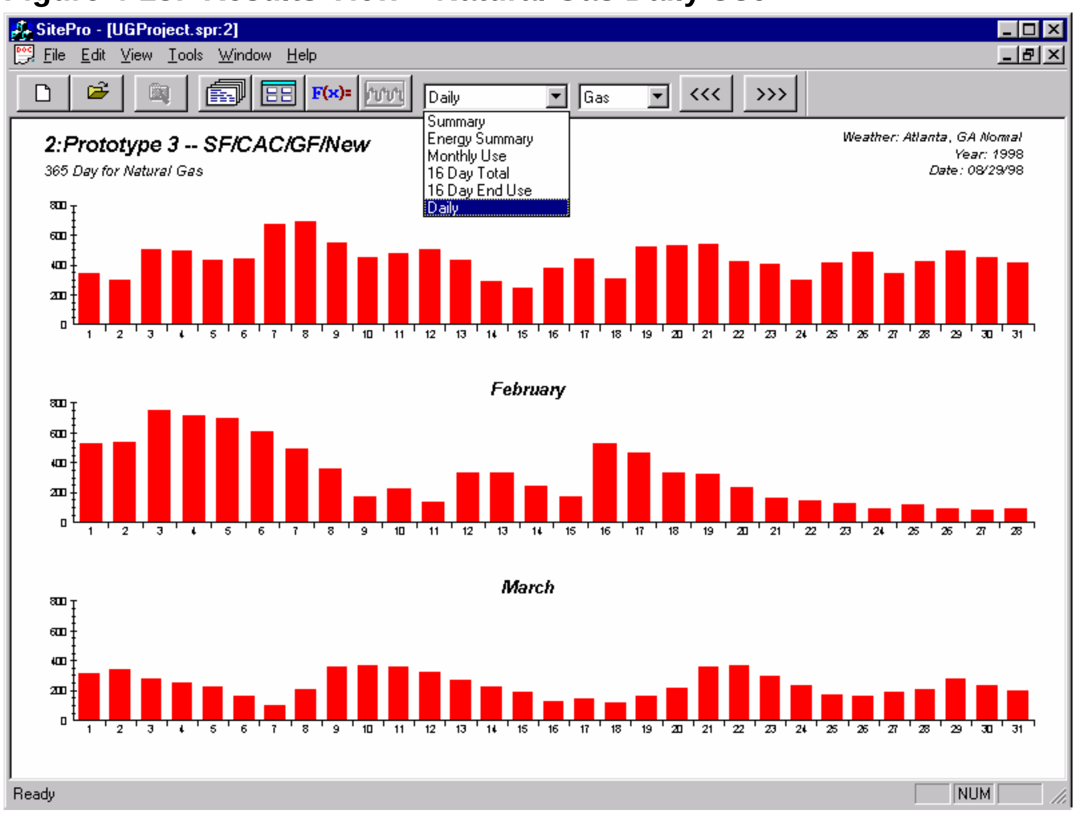


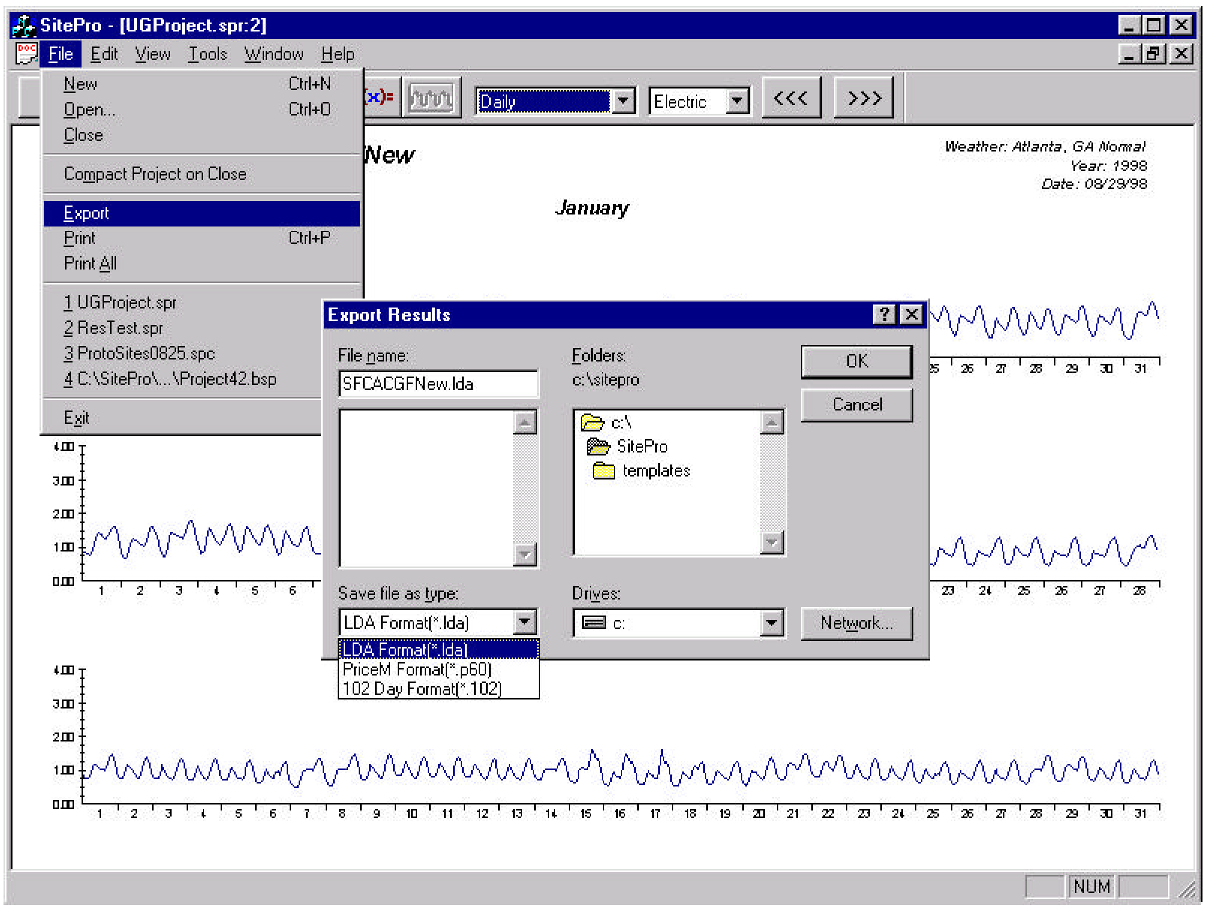
Figure 4-18: Results View – Natural Gas Daily Use



4.6 Export Results

All load shape results are stored in tables in the project file. For residential projects, the project file extension is .spr. These files are in Microsoft Access format, so they can be viewed, analyzed, and used through the Access interface. In addition, whole-building hourly load shapes may be exported to an LDAW format (.lda), 102 Day format (.102), and Pricem format (.pcm). To do this, select File→Export from the 8,760-hour graph. The result will be as shown in Figure 4-19. Select the file type for the export action, enter a file name and press OK.

Figure 4-19: Exporting 8,760 to File in LDA Format



4.7 Saving End-Use Hourly Loads

In addition to the whole-building results, it is possible to save 8,760 results for individual end uses. This is done by selecting Tools→Save End-Use Detail. When this option is on, all 8,760 values for the end-use loads that have been selected are appended to an Access database that has the same name as the residential project file with a .mdb extension added.

To identify the end-uses and fuels to save, select Tools→EU Detail Options. This action will bring up a dialog with a series of check boxes for electric end uses and for gas end uses. Select the desired options. Press the *Save As Default* button to make this the default selection. Press OK to install the options for the current session.

4.8 Print Results

Results can be printed one page at a time or in batch. To print a single page, select the desired chart and select File→Print. To print the entire set of charts for a site, view results for the desired site and select File→Print All. Finally, to have results printed automatically whenever a site is simulated, select Tools→AutoPrint. To set the results that should be included in the automatic printing use the Tools→AutoPrint Options.

5

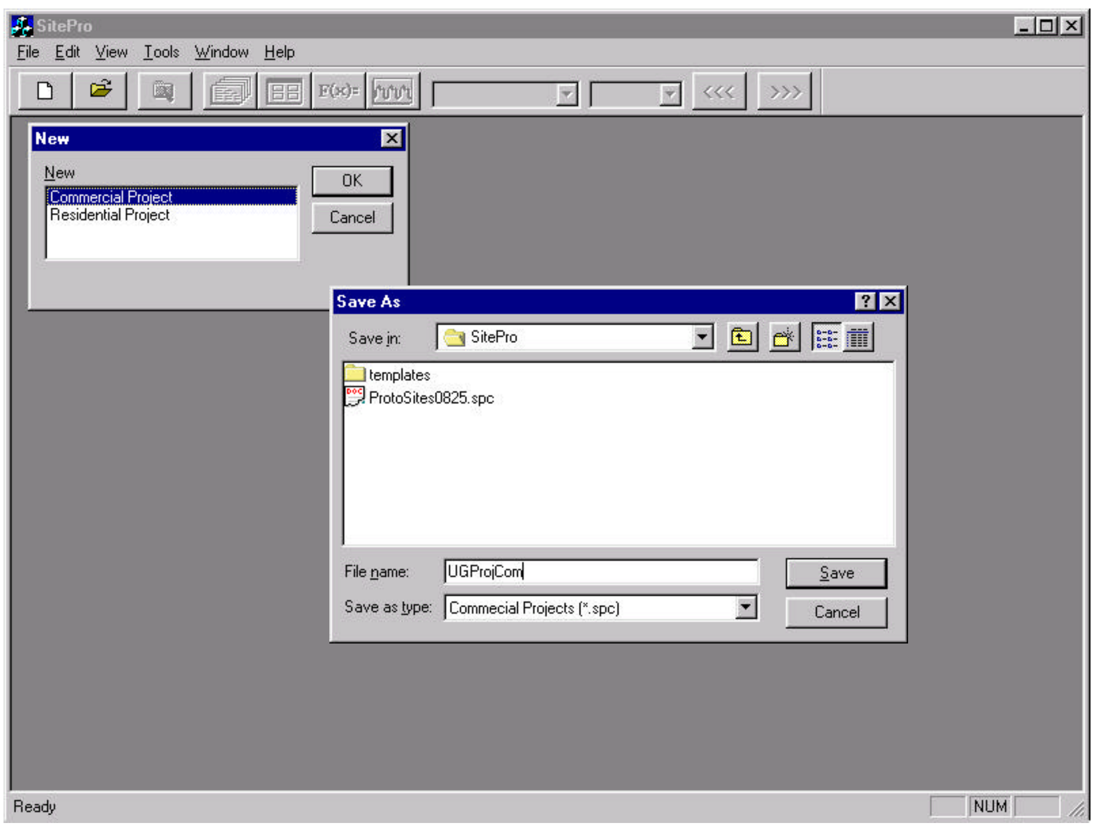
Commercial Simulation Module

This section describes the steps for executing the commercial simulation component of SitePro. A general discussion of features common to all modules is presented in Section 3. This section focuses on features that are specific to the commercial module.

5.1 Execute SitePro

When SitePro is started, it will automatically connect to the database server and present the main program screen. Once the main program screen is shown, the user may create a new project by selecting File→New from the menu or by pressing the "New" button on the SitePro toolbar. As shown in Figure 5-1, this will bring up a selection dialog that provides a

Figure 5-1: Creating a New Commercial Project



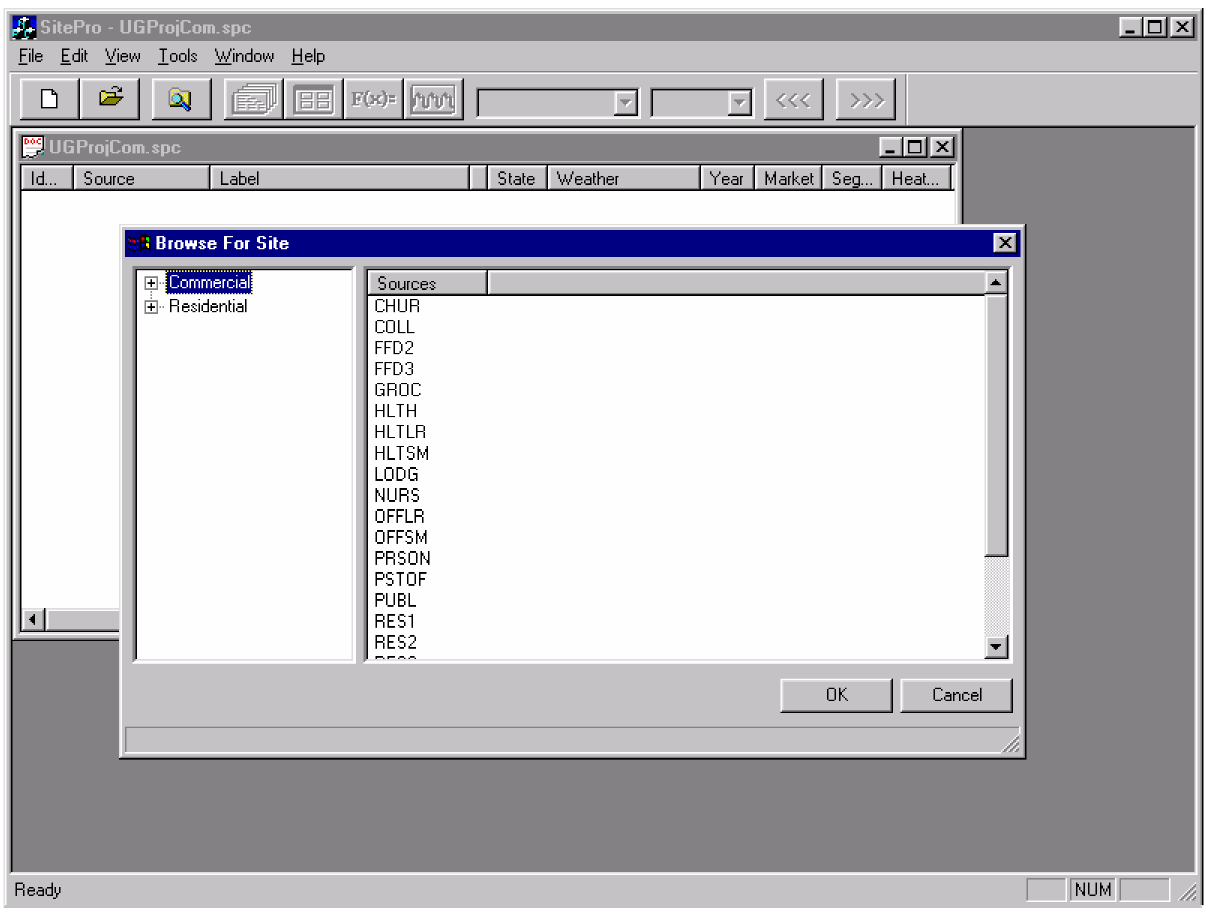
list of the three types of projects. Select the Commercial option. A "Save As" dialog will then be provided. Enter a directory and file name. This will result in creation of an empty project database.

To open an existing project, select File→Open from the menu or press the "Open" button on the SitePro toolbar. This will result in a standard file open dialog. To select a commercial file, search for files with a .spc extension.

5.2 Adding Sites to the Project File

When a new project is started, it is empty, and there are no sites in the project database. An existing project typically will contain some number of sites. In either case, the Browse feature is used to add sites from the prototype library on the database server. For commercial projects, the browsing action, which is illustrated in Figure 5-2, proceeds as follows.

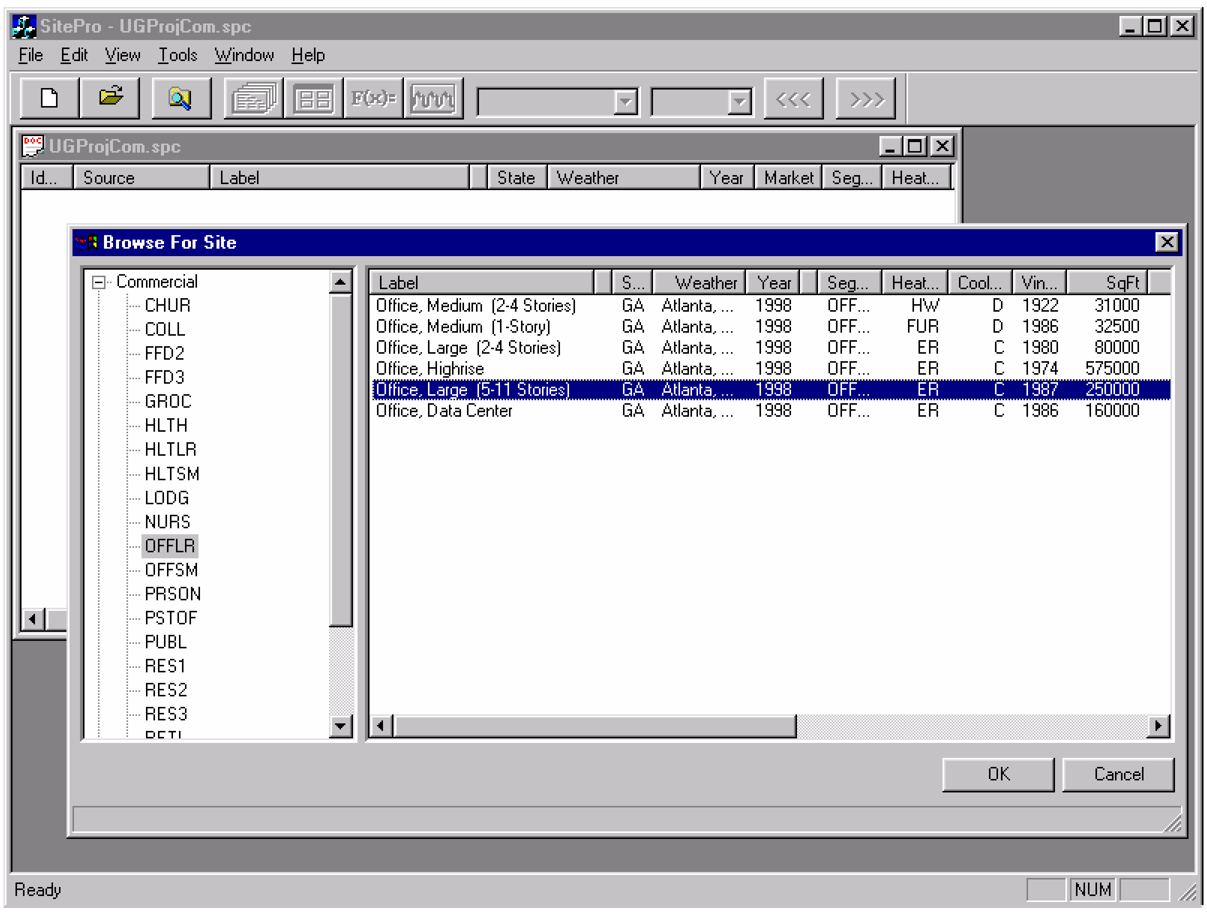
Figure 5-2: Select a Prototype Library



Select a Prototype Library. From the project view, click on the "Browse" button. A tree control will be provided indicating all prototype libraries that are registered and available to the user. Select the library of interest by double clicking on the library name or by expanding the segment list for that library.

Select a Segment. After making a library selection, a list of segments in the library will appear in the right hand panel or below the library label, as shown in Figure 5-3. The aspect of the database that is used for segmentation is configurable by the system administrator. In the example shown, building type segmentation is used, and the large office segment (OFFLR) is selected.

Figure 5-3: Selecting a Site



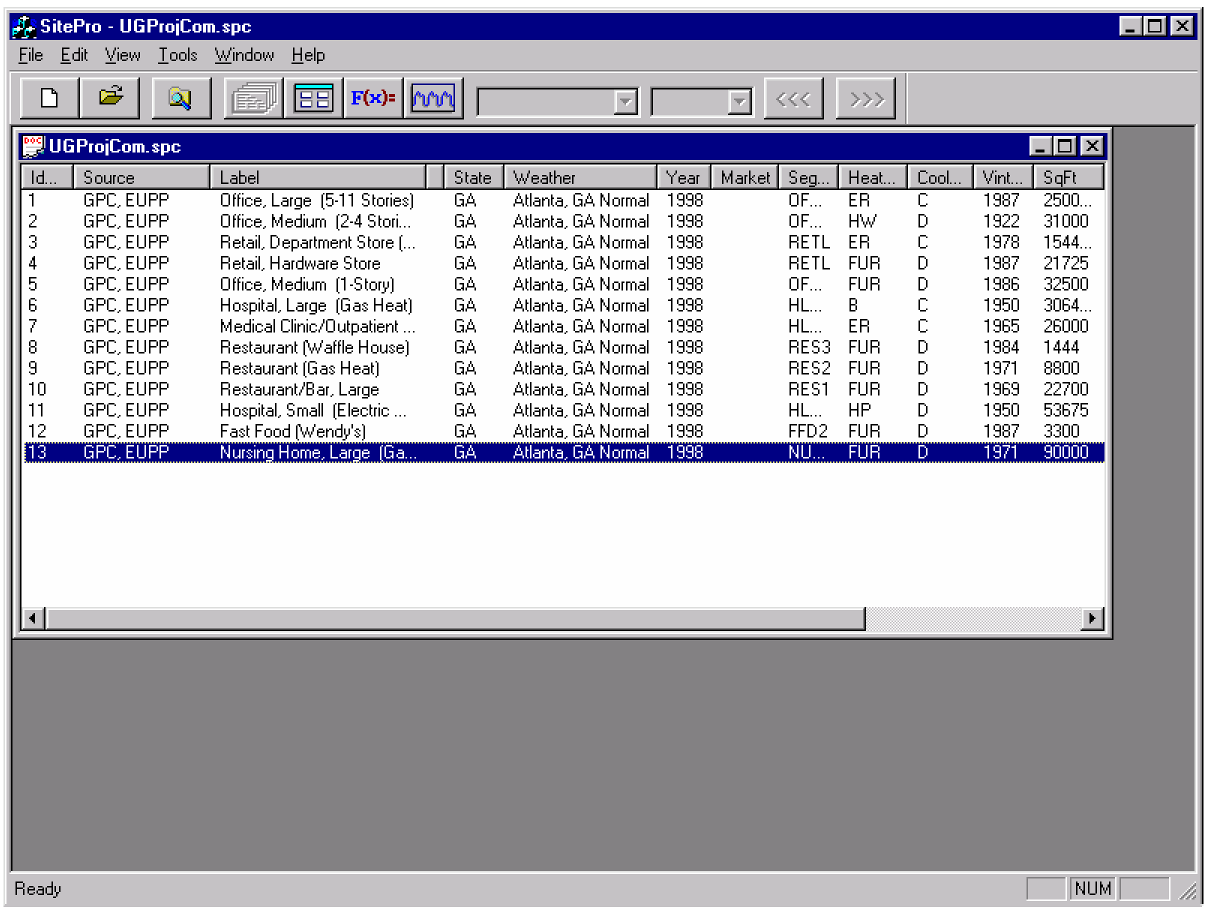
Select a Site. By selecting a segment, a filtered list of sites in the prototype library is presented. The user should choose a prototype site for inclusion in the user project by clicking on the site and selecting "OK." To make the selection process easier, key prototype characteristics are provided. For the commercial segment these characteristics include the following:

- Site name or label
- Site weather and weather year
- Segment (building type in the example libraries)
- Heating Equipment and Cooling Equipment
- Building Vintage
- Building Size

It is possible to sort the filtered list of sites by clicking on any of the column headers. A single click sorts in ascending order. A second click sorts in descending order. Column widths can be adjusted by clicking on the sides of the column headings and dragging them.

Once a site is selected, SitePro will return to Project View, which shows the list of sites that have been included in the project portfolio. These sites are included in the project database, and each site is marked as either Needs Simulation or Up To Date.

Figure 5-4: Example of Project View



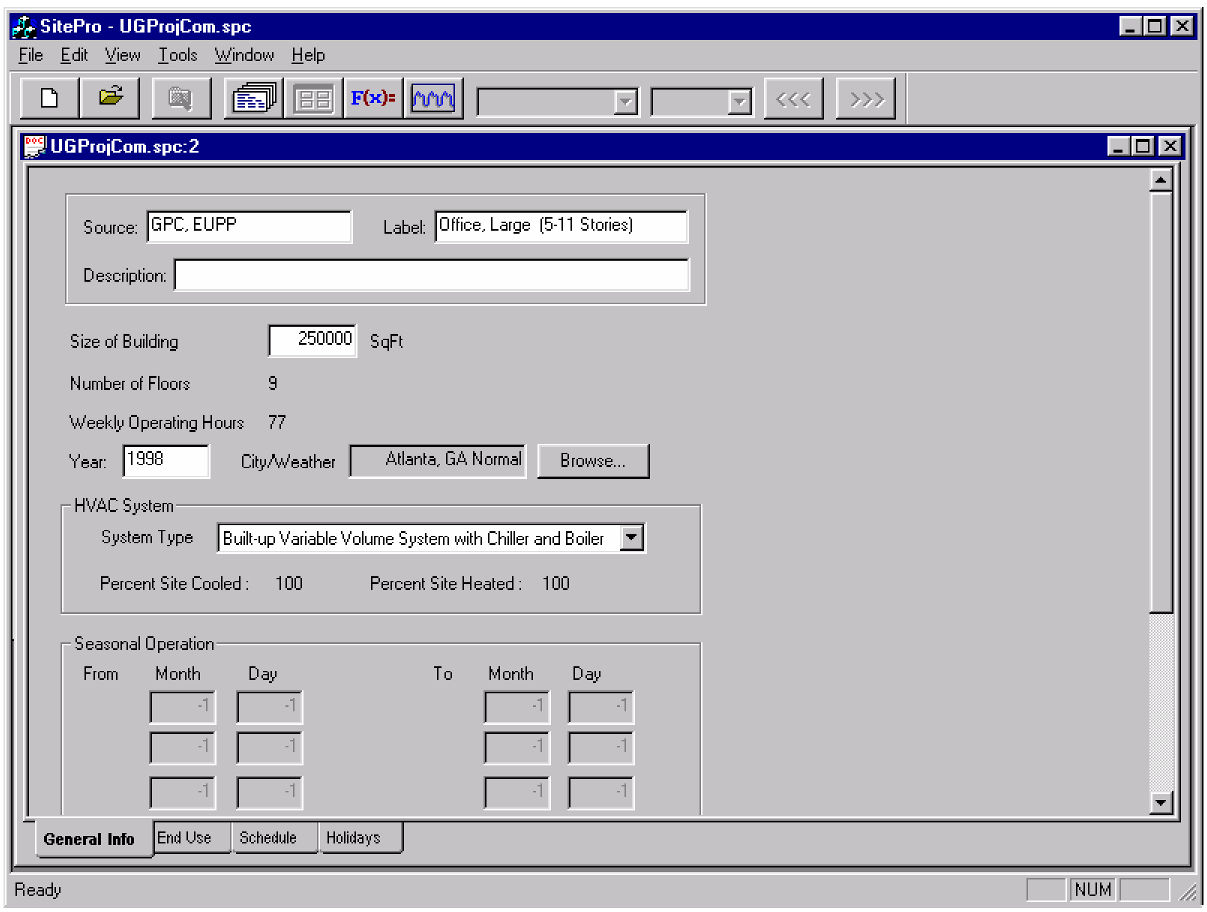
This field comes from the prototype libraries as Up To Date, indicating that the load shapes in that are copied to the project file are consistent with the characteristics data that are copied to the project file.

5.3 Review, Modify and Save Site Characteristics

Once a site is included in the project, its characteristics can be viewed or modified. To view or modify the characteristics, highlight the site and press the "View Data" button on the SitePro toolbar, or double click on the site in the project portfolio. Either action results in creation of a tabbed dialog containing four tabs. Examples of these tabs are shown in Figure 5-5 through Figure 5-7. Changes are saved when the user closes the window or executes a simulation. The characteristics window may be closed using the "X" in the upper right hand corner of the window.

General Information Tab. The general information tab (Figure 5-5) presents the following information for the selected site. While the site may have default information based on the specifications in the prototype library, the user may revise the majority of the key characteristics as needed to represent a modified site.

Figure 5-5: View Data – General Information Tab



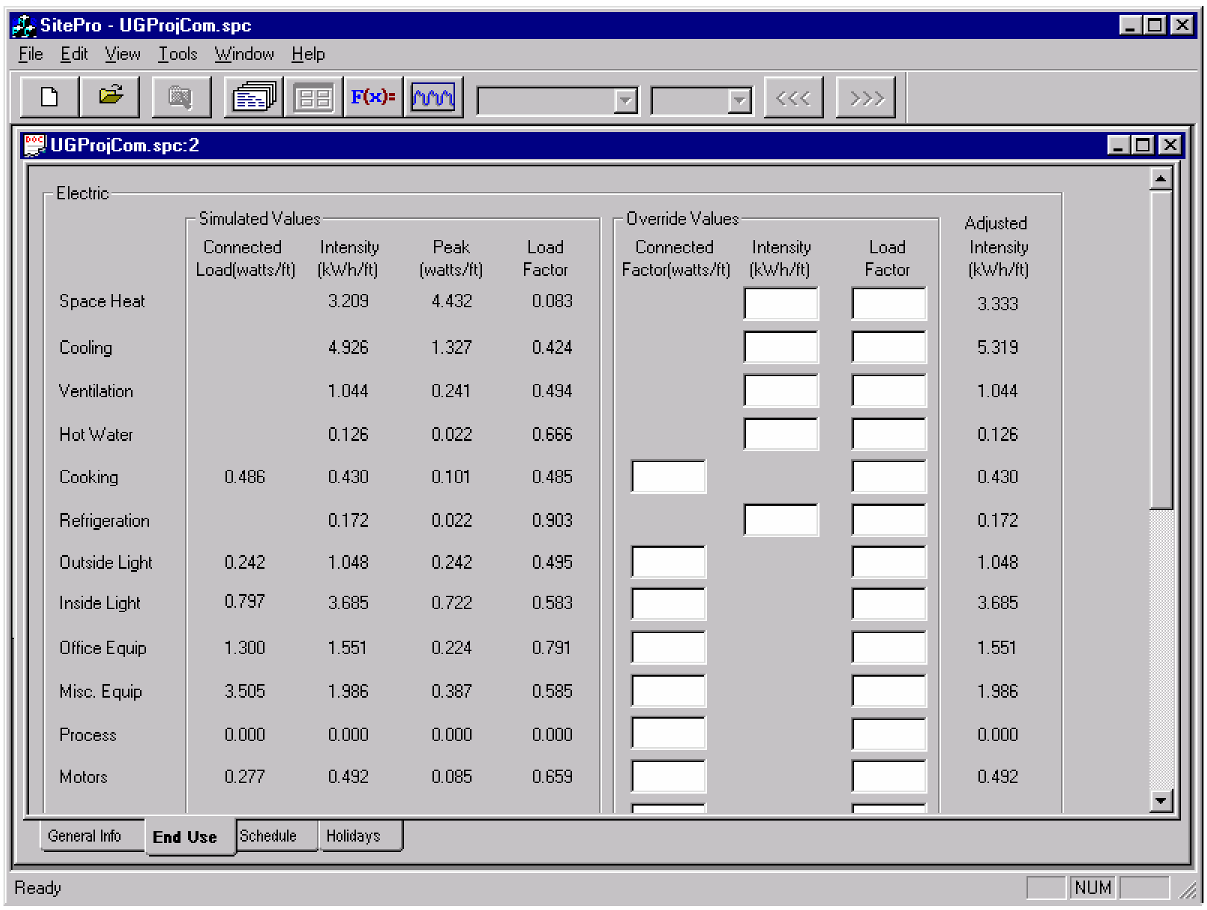
- ***Source*** is a field intended to document the original source of the prototype
- ***Label and Description*** are the name and description fields for the site
- ***Size of Building*** is the building size in square feet
- ***Number of Floors*** is the number of floors used to represent the building
- ***Weekly Operating Hours*** is a computed field summarizing building operation
- ***Year*** is the calendar year that will be used in the simulation. The hourly simulation results will be placed on a calendar that represents the timing of weekends and holidays for that site.
- ***Weather*** is the weather file that is used in the simulation. The weather station can be changed by using the browse feature. This accesses the database server to provide a list of available files for each state.
- ***HVAC System*** identifies the primary heating and ventilation at the site. The user can change systems within the single zone family, according to options allowed in the drop-down list. Complex systems can not be changed.
- ***Percent Site Cooled*** indicates the fraction of the floor space in the prototype that is cooled. This field can not be edited.
- ***Percent Site Heated*** indicates the fraction of the floor space in the prototype that is heated. This field can not be edited.
- ***Seasonal Operation*** indicates the calendar periods for which the secondary operating profile should be applied. For example, to have the secondary schedule apply from June 15 to September 1, enter 6, 15, 9, and 1 in the four fields. Up to three intervals for application of the secondary schedule can be identified.

End-Use Tab. The end use tab shown in Figure 5-6, presents end use energy results for electricity and natural gas end uses. The data appear in six columns. The first three columns show simulated values, which are based on the modified characteristics data and weather data. The next two columns provide end-use override variables. The final column shows the final intensity after application of the override variables. The fields are:

- ***Intensity.*** This field shows the engineering estimate of the annual energy intensity, expressed in kWh per square foot for electric uses and in kBtu per square foot for natural gas.
- ***Peak.*** This field shows the largest simulated hourly value for an end use. The hour of the peak value is determined separately from the end-use load shape. The value is in Watts per square foot for electricity and Btu per square foot for natural gas.
- ***Load Factor.*** The load factor is the average hourly load divided by the peak value for each end use.

- ***Intensity Override.*** The intensity override is a multiplier. For example, if this value is 1.2, the loads for the specified end use will be marked upward 20% in each hour. If a load factor adjustment is specified, it is applied first, and the intensity override is applied subsequently.
- ***Load Factor Override.*** This load factor override is applied before the intensity override. It is applied in a way that the peak value is maintained and energy values are adjusted upward or downward proportionally to their distance from the peak value, which increases or decreases the annual intensity. Downward adjustments are capped at zero, and if this limit is encountered, the desired load factor will not be realized.
- ***Adjusted Intensity.*** The adjusted intensity represents the end-use intensity after the intensity and load factor overrides have been applied.

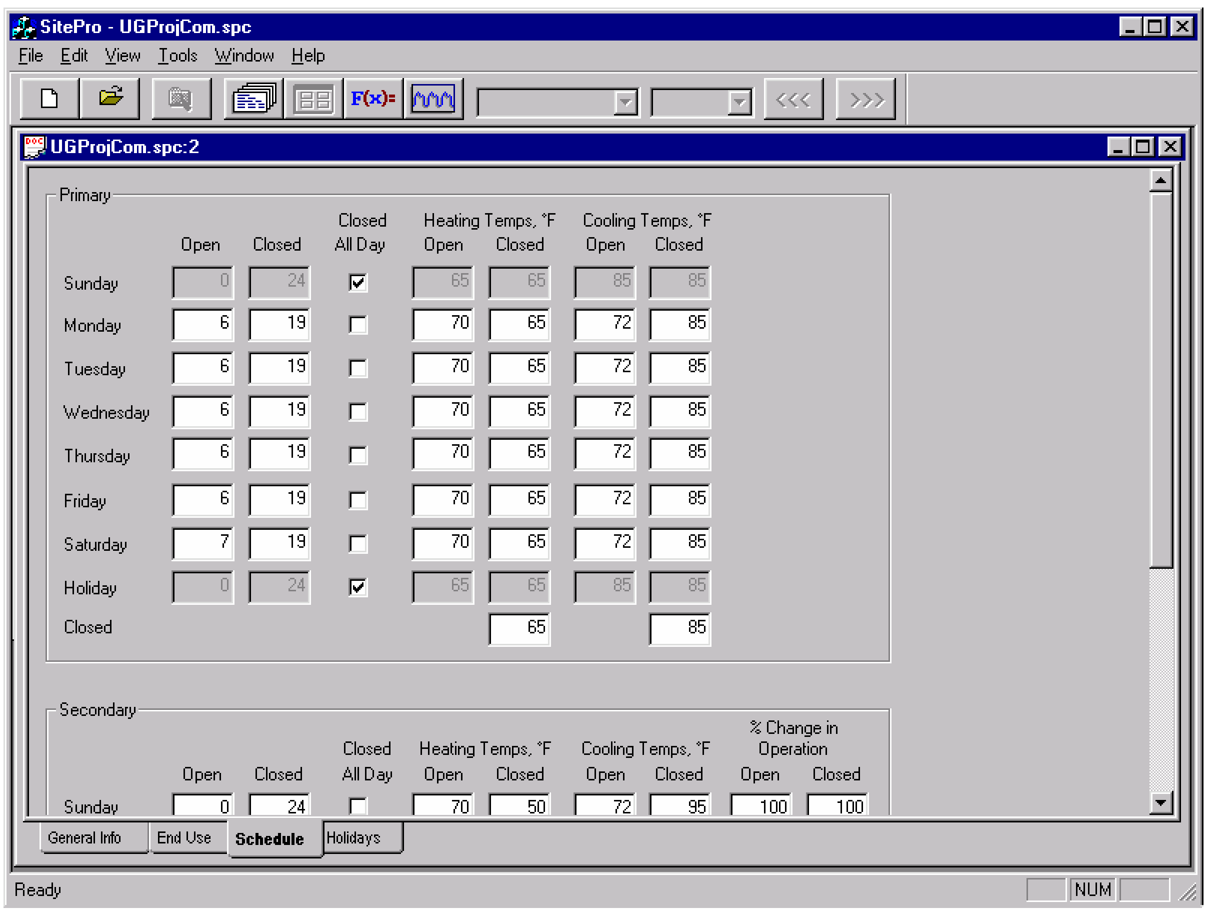
Figure 5-6: View Data – End-Use Tab



Schedule Tab. The schedule tab is shown in Figure 5-7. This tab allows the user to modify the start and stop times for each day of the week, as well as thermostat settings and schedules for heating and cooling. Features of this tab are as follows:

- ***Open and Close Hours.*** These fields control the time a building opens and closes for each day of the week. If the closed-all-day option is checked, the values are dimmed, and the hour settings for the closed day are used in the simulation. These values are used to adjust the "starter shapes" in the technology databases for non-HVAC uses.
- ***Closed All Day Checkbox.*** By checking this box for a day of the week, the thermostat settings for the closed are assigned to that day.
- ***Heating Temperatures.*** These values indicate thermostat settings for heating equipment during the specified hour range. Values are entered in degrees F, and a value of 50 or lower indicates that the system is off.
- ***Cooling Temperatures.*** These values indicate thermostat settings for cooling equipment during the specified hour range. Values are entered in degrees F, and a value of 95 or higher indicates that the system is off.

Figure 5-7: View Data – Schedule Tab



Below the primary schedules is a set of secondary schedules. These inputs have the same format, but two extra fields are added. The additional fields are labeled "% Change in Operation." Separate entries are provided for open hours and closed hours.

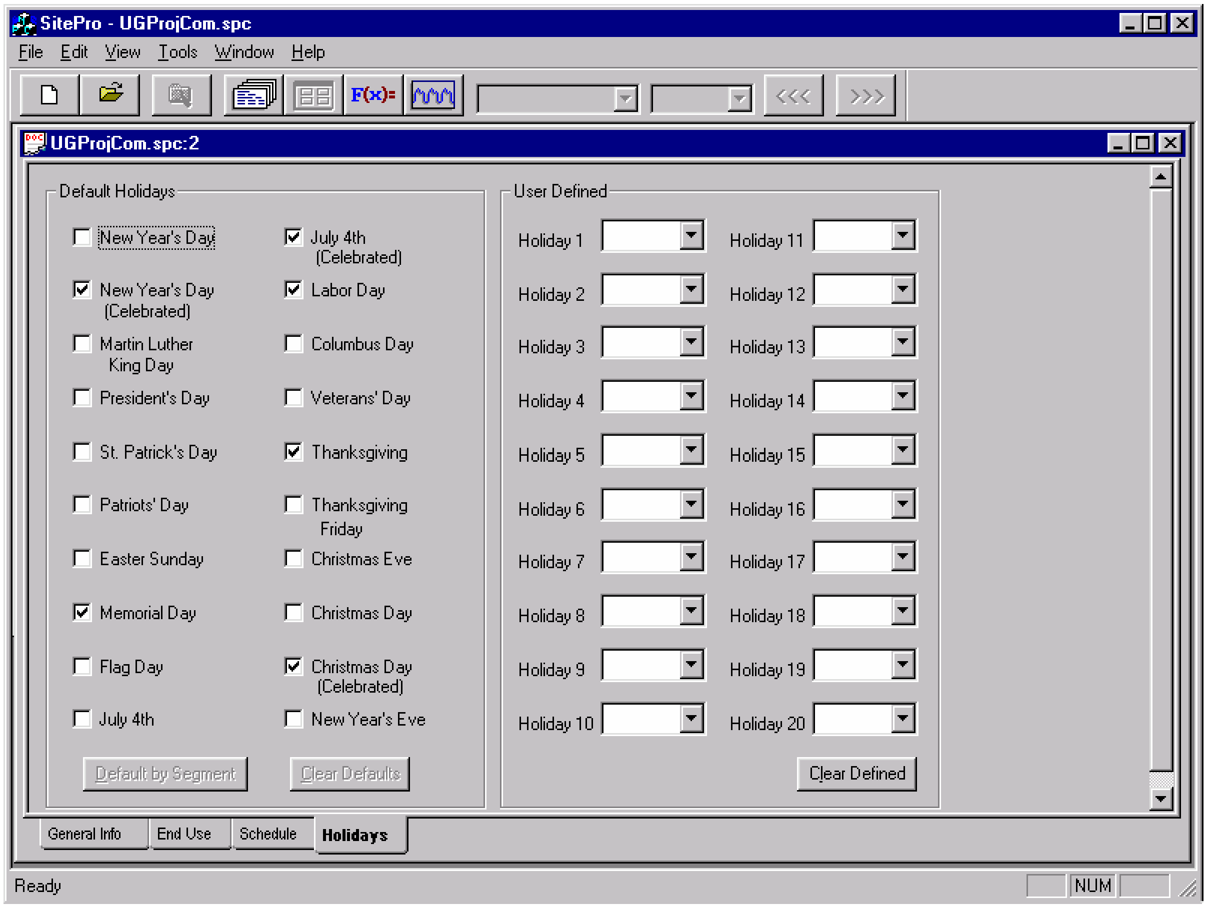
- The value for open hours is applied to the peak value of the starter shape in the technology database for non-HVAC uses. By entering a value of 60, the peak value will be reduced to 60% of its initial value.
- The value for closed hours applies to the base value in the end-use shape. By entering a value of 40, the base value is reduced to 40% of its initial value.

These shape modifications to the base and peak values are applied to recalibrate the starter shape. Then the starter shape is further modified to agree with the operating hour settings for the secondary schedules.

Holiday Tab. The holiday tab (depicted in Figure 5-8) allows the user to specify which of a list of 20 standard holidays apply to the site. In addition a list of up to 20 additional dates can be supplied.

The schedule data are stored separately for each site in the project, allowing full flexibility across types of commercial activity. The actual dates on which the standard holidays occur is controlled by a calendar table that is located in the technology data file.

Figure 5-8: Holiday Schedules

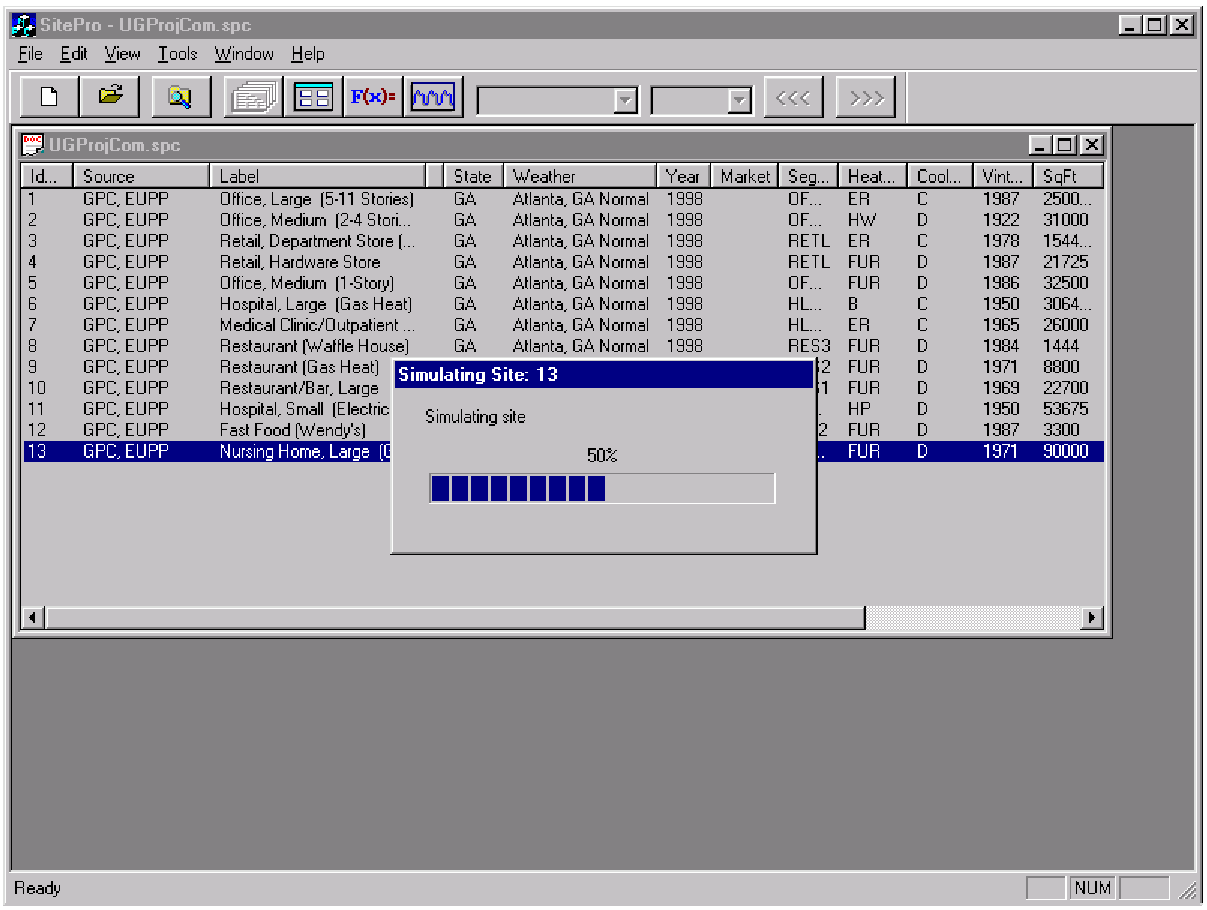


5.4 Execute Energy Simulation

Once the site data in a project portfolio have been obtained and edited, the user may execute the energy simulation step of SitePro. The simulation may be executed from the project view or from the data view for a site. From the project view, highlight the desired site (as shown in Figure 5-9) in the project and select the "Simulate" button. After the simulation is complete, results may be viewed by pressing the "Results" button. To execute a simulation from the data view, simply press the "Simulate" button and when the simulation ends, the results will appear on the screen.

From the project view, multiple sites may be simulated in a batch mode process. This is done by selecting multiple sites using the Shift key and pressing the "Simulate" button.

Figure 5-9: Execute Simulation



SitePro performs a full hourly energy simulation using DOE-2 and proprietary non-HVAC algorithms. The basic simulation logic is summarized below.

- SitePro estimates hourly loads for all non-HVAC equipment. These simulations are based on the characteristics data and technology inventory data in the project file database and end-use load shapes in the technology database on the database server.
- Along with estimates of internal gains from the non-HVAC simulations, the project file provides all the site data required to simulate HVAC energy use in DOE-2.
- Weather data for these simulations is obtained from the weather directory on the database server.
- The simulation delivers load shapes for 8,760 hours for each end use.

5.5 Review and Print Results

To view results from the user project, highlight a site and select the "Results" button. If data have been changed since the site was last simulated, the user will be prompted about whether to perform a simulation. To see revised results with the edited data, select "Yes." This will result in a simulation of the site. To see the most recent simulation results that do not incorporate subsequent edits, select "No." In this case a simulation will not be executed and the old results will be displayed.

When results are viewed, the Energy Summary for Electricity appears, as shown in Figure 5-11. While viewing the results, the two pull-down menus on the Toolbar provide access to the following graphs for electricity and natural gas.

- ***Energy Summary*** illustrates shares, annual intensity values, peak values and, and percent of total sales for each end use and the whole site.
- ***Monthly Use*** presents monthly energy use and maximum hourly demand for each month of the year.
- ***16-Day Total*** presents whole-site load shapes for 16 day types.
- ***16-Day End Use*** presents end-use load shapes for 16 day types.
- ***8,760 Hour*** presents whole-site hourly loads, three months at a time. The double arrows allow the user to view additional months.

Review results graphs are illustrated in Figure 5-11 through Figure 5-21.

Results for multiple sites can be viewed side-by-side by selecting each site on the project view and pressing the Results View button. Graphs for each site will be in their own window, and windows can be sized and tiled as desired.

Figure 5-10: Results View -- Summary

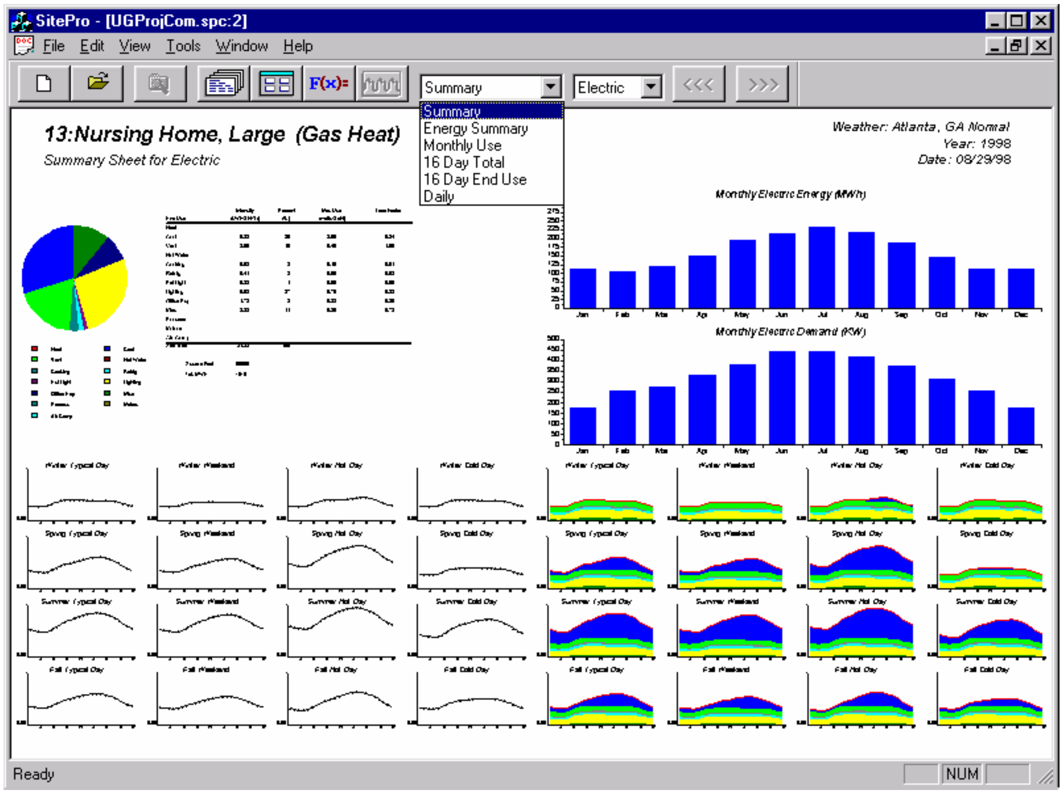


Figure 5-11: Results View – Energy Summary

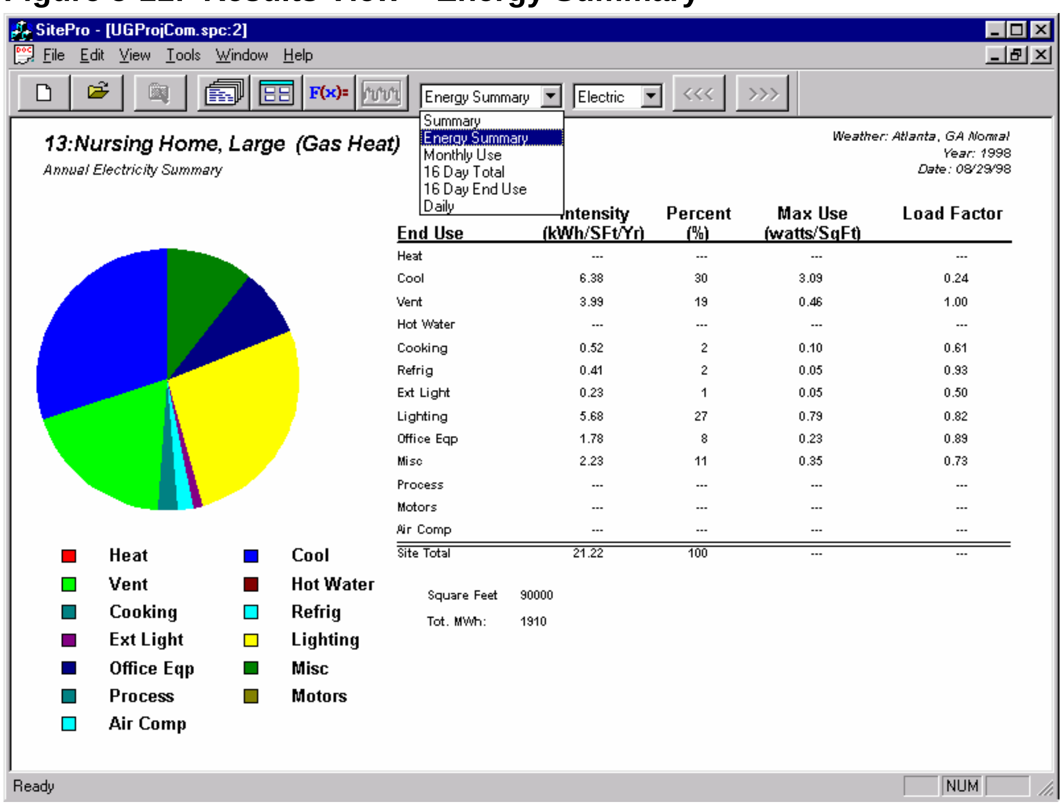


Figure 5-12: Results View – Monthly Use

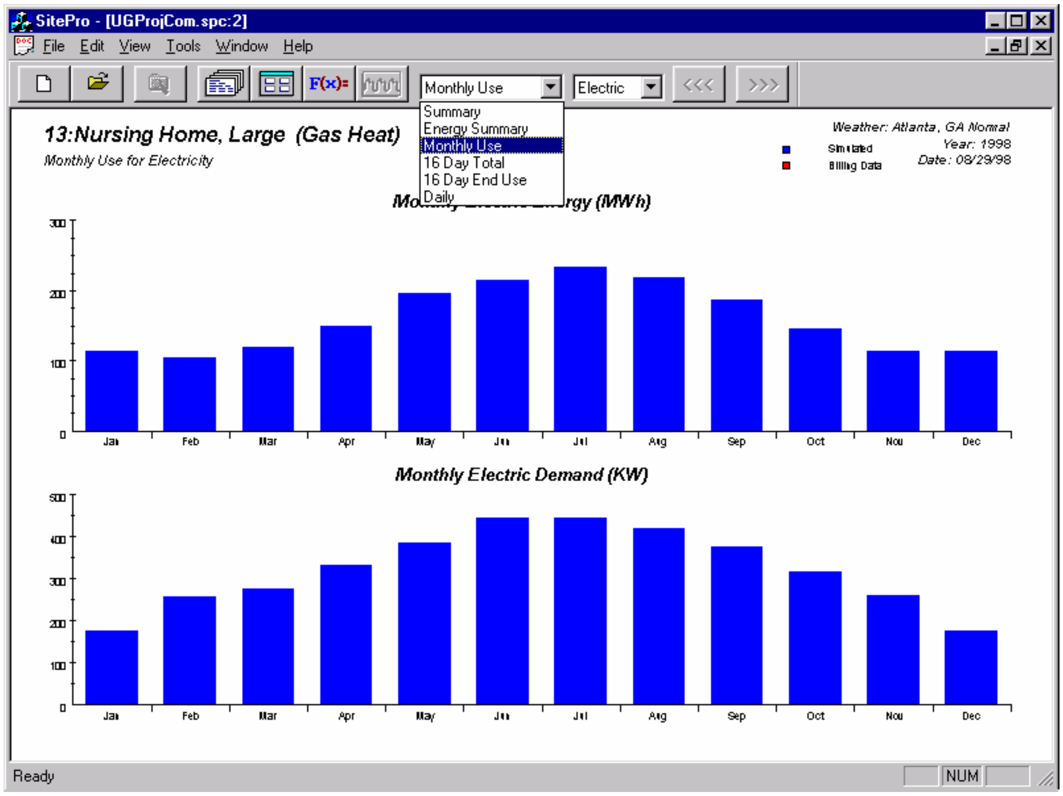


Figure 5-13: Results View – 16-Day Total

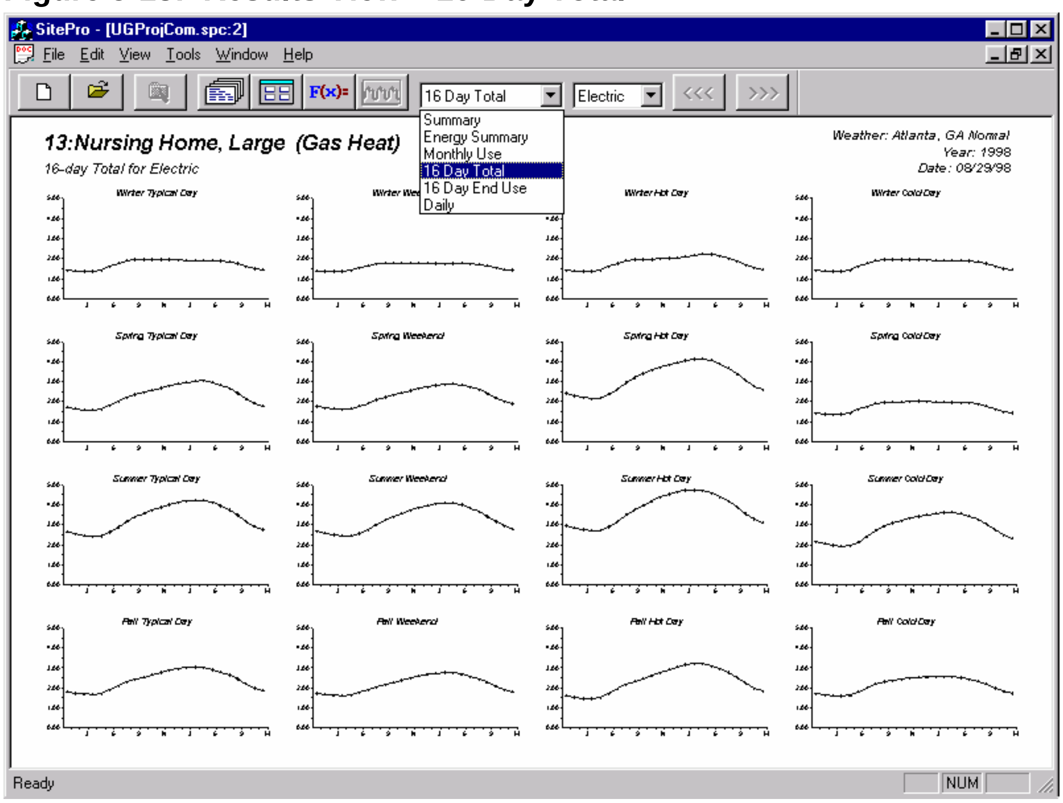


Figure 5-14: Results View – 16-Day End Use

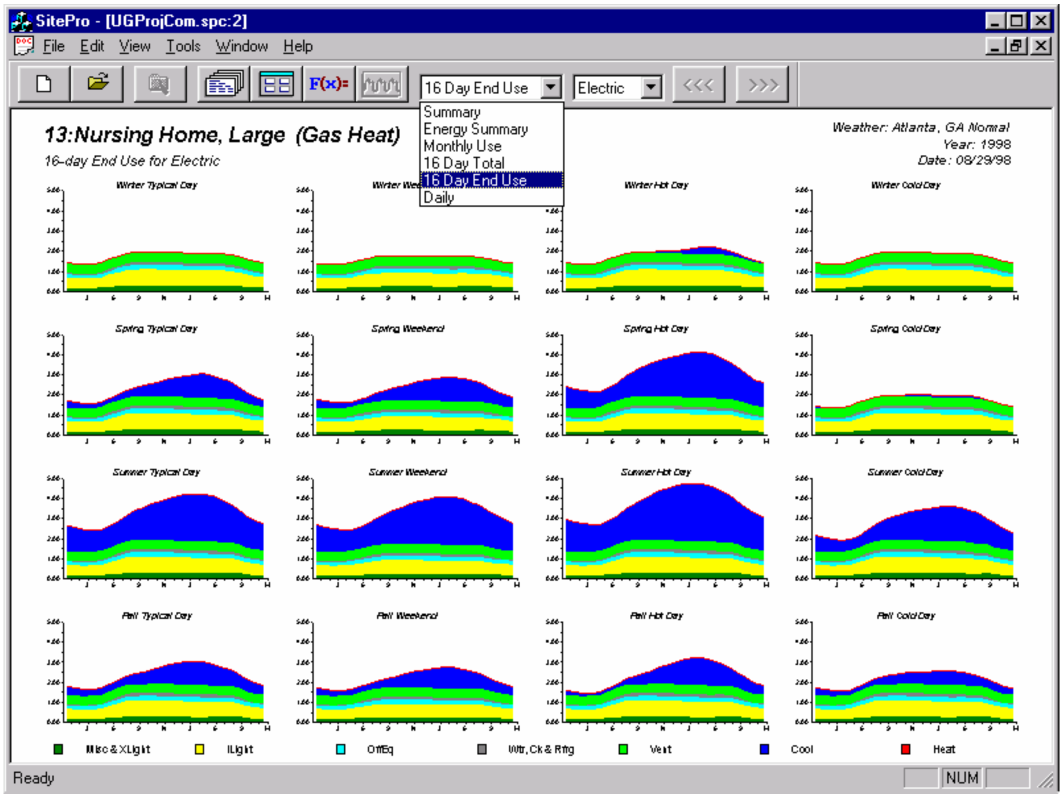


Figure 5-15: Results View – Daily

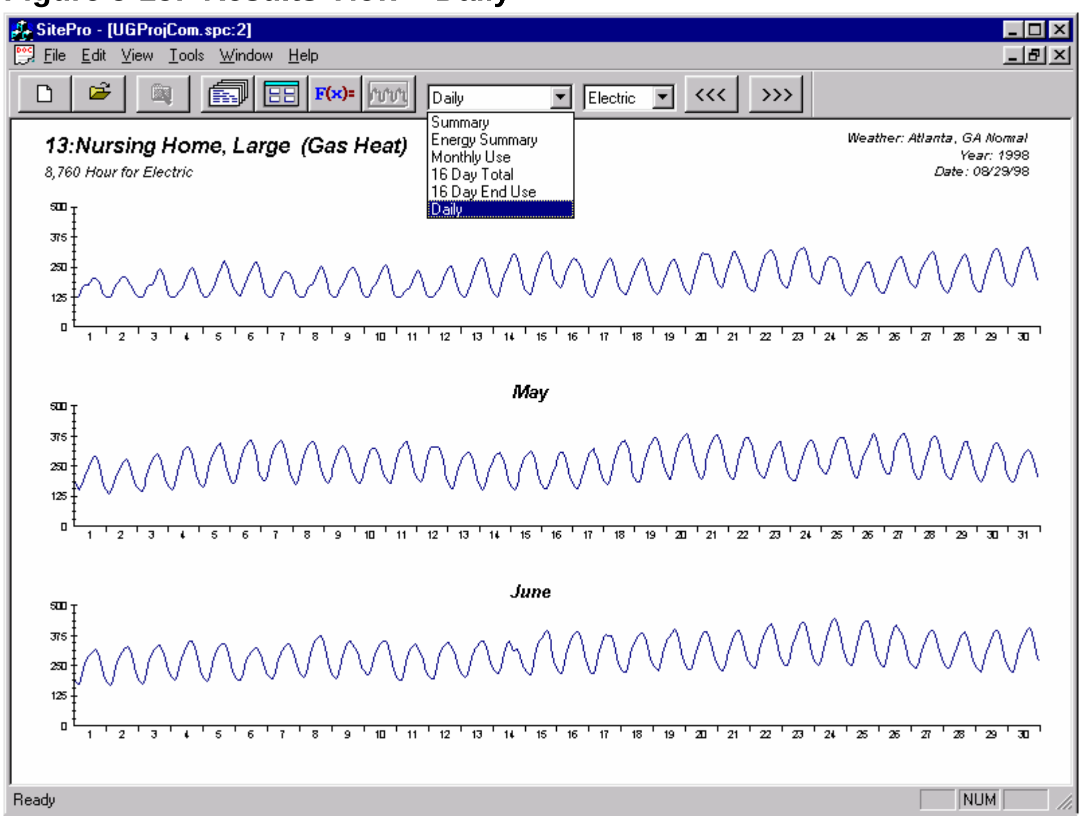


Figure 5-16: Results View – Natural Gas Summary

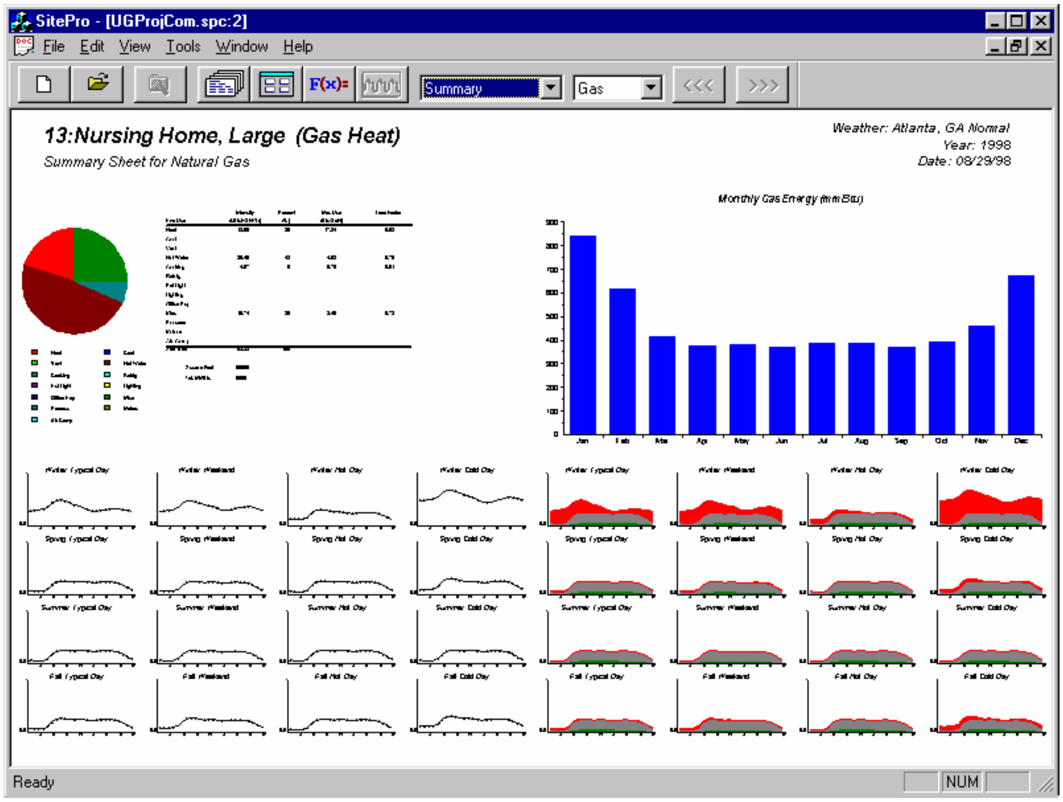


Figure 5-17: Results View – Natural Gas Energy Summary

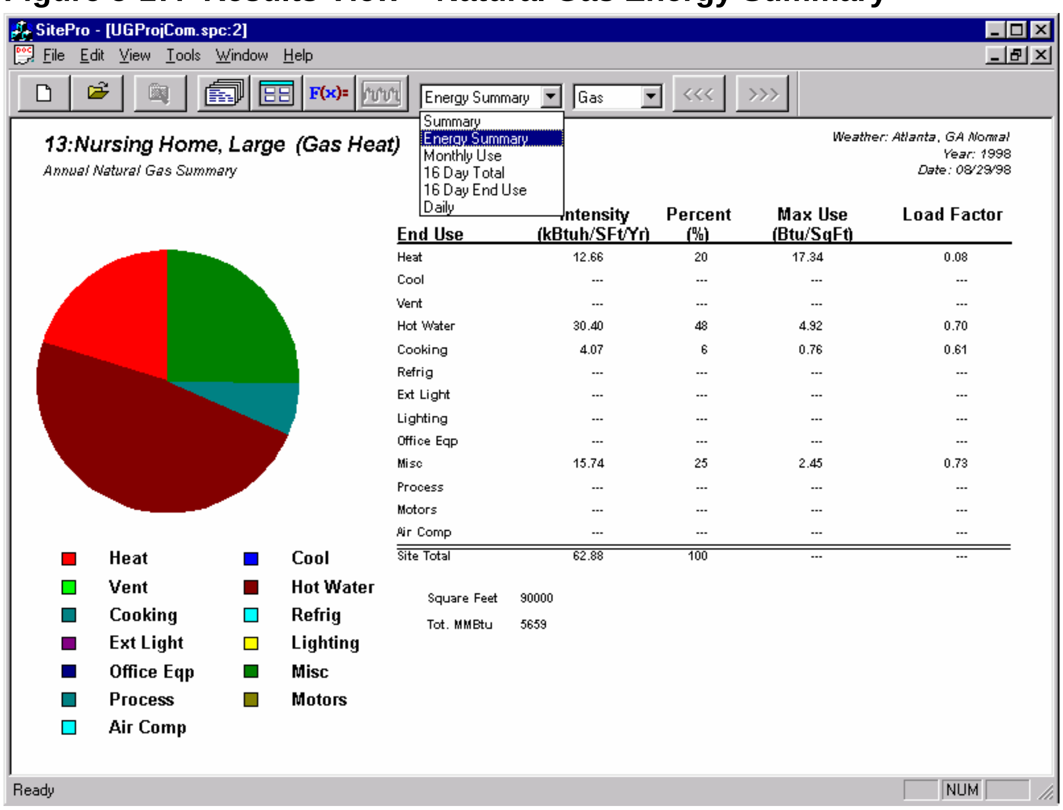


Figure 5-18: Results View – Natural Gas Monthly Use

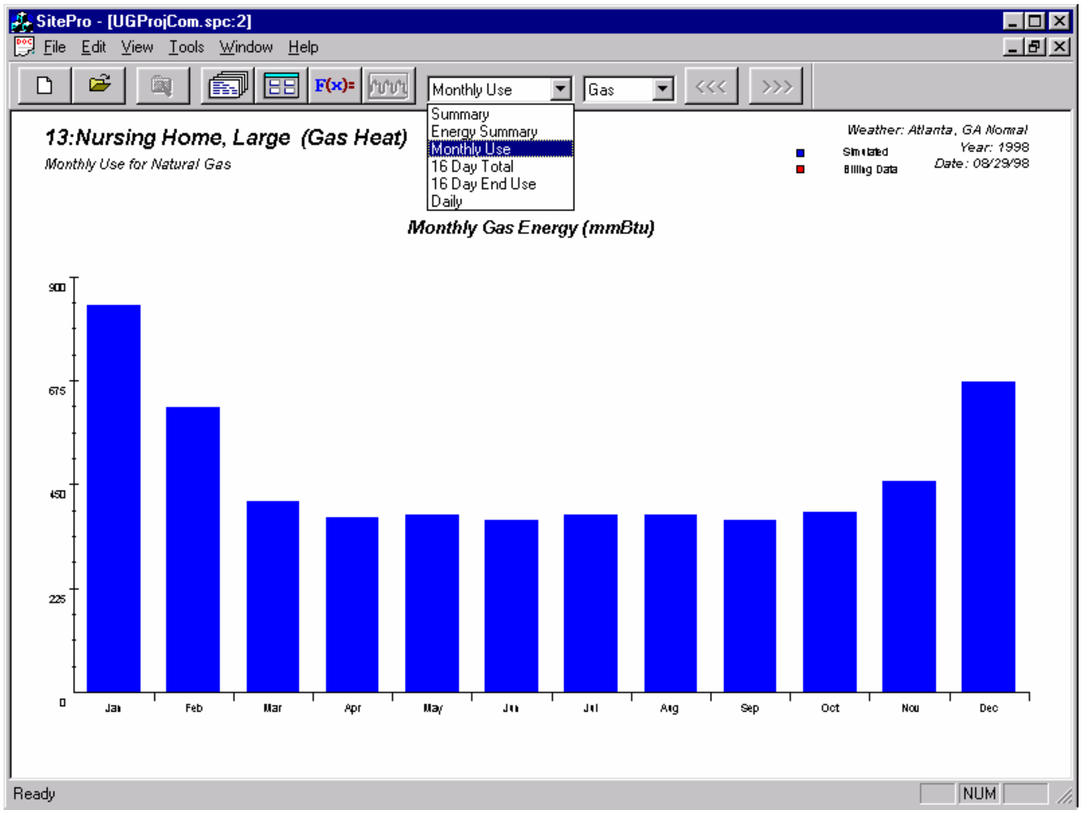


Figure 5-19: Results View – Natural Gas 16-Day Total

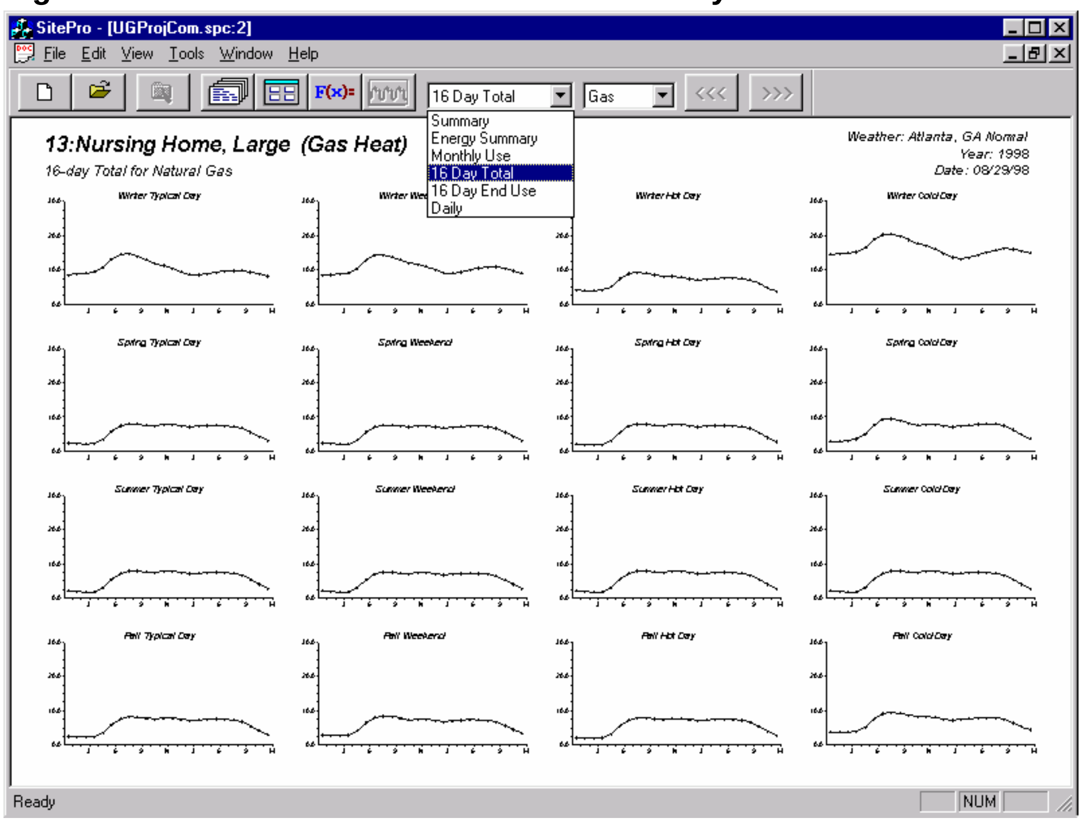


Figure 5-20: Results View – Natural Gas 16-Day End Use

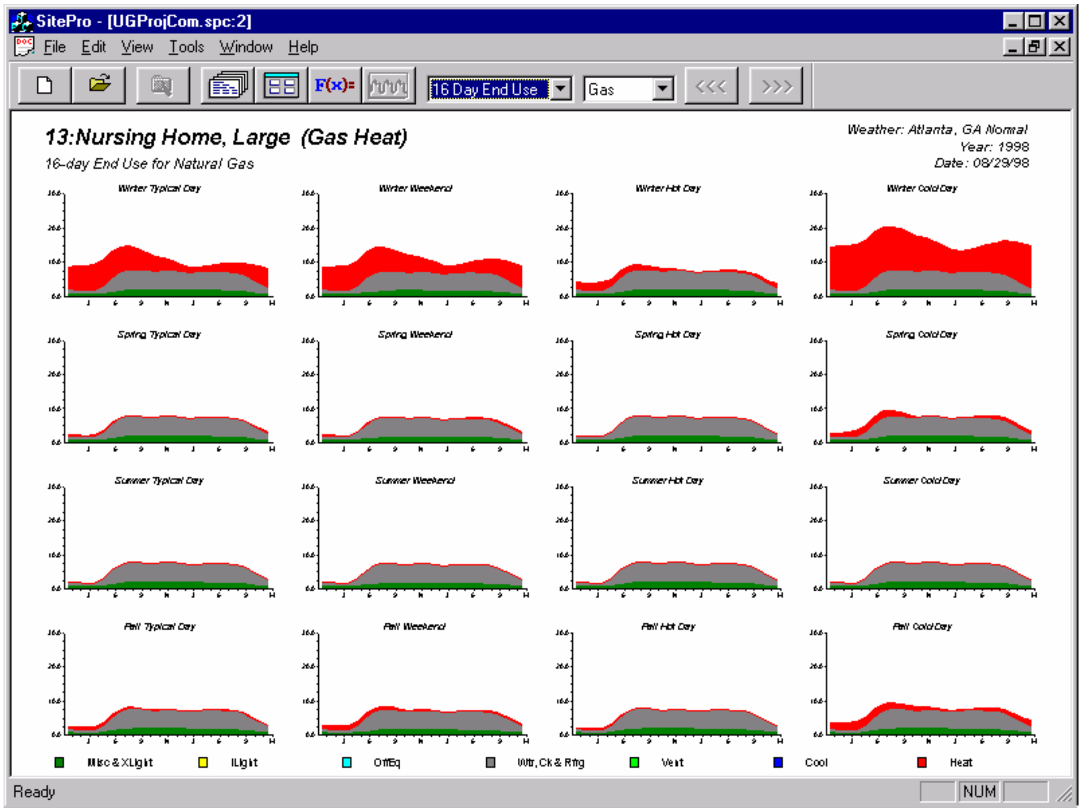
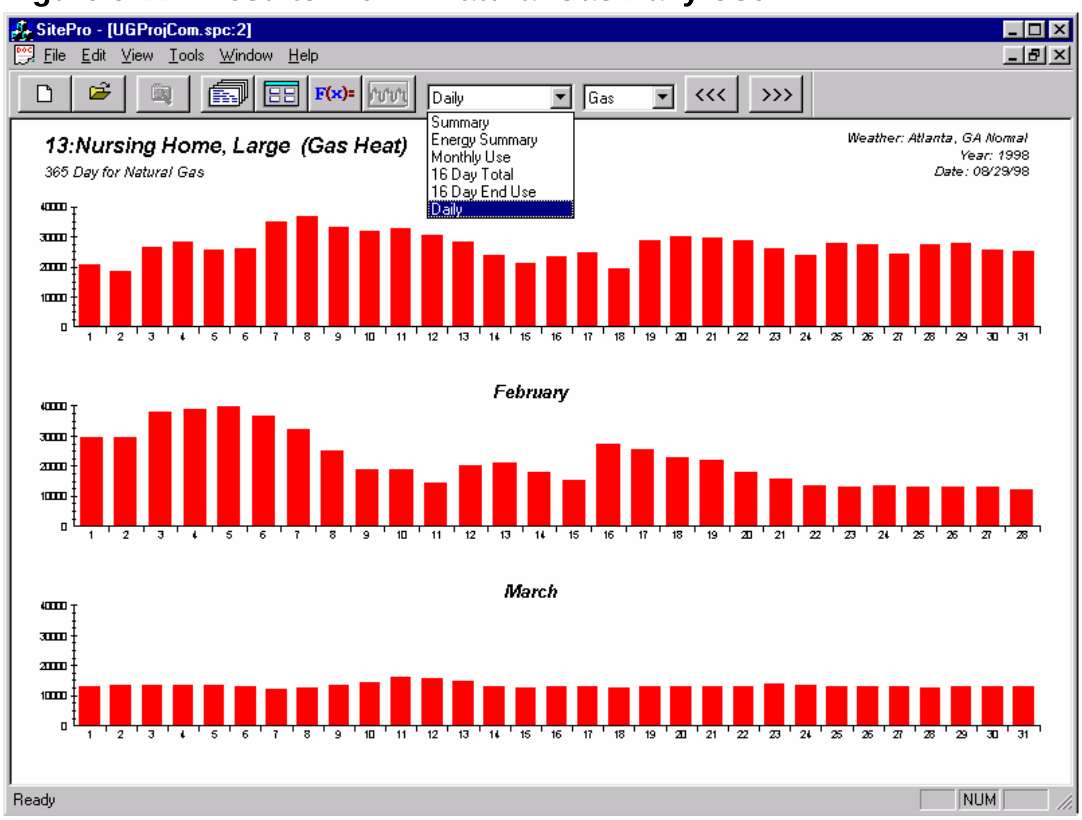


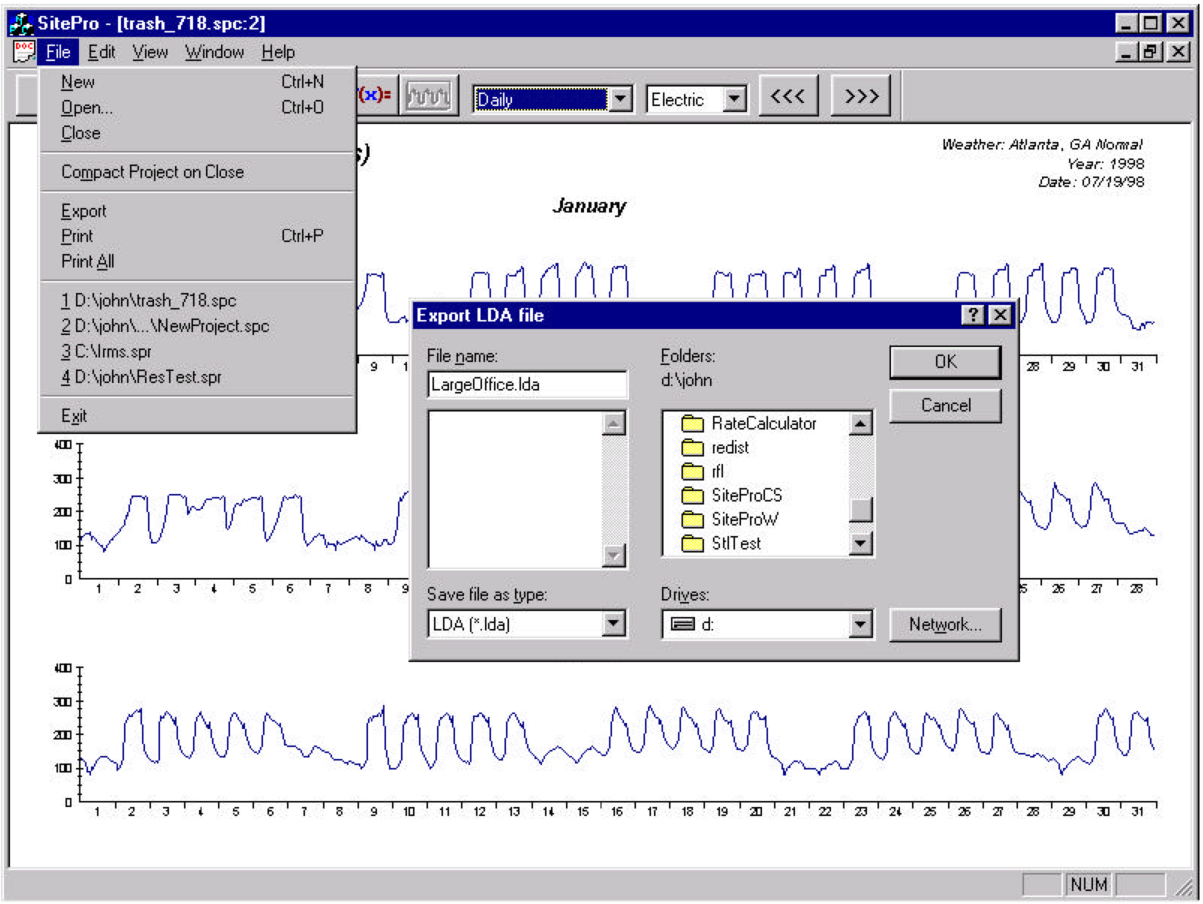
Figure 5-21: Results View – Natural Gas Daily Use



5.6 Export Results

All load shape results are stored in tables in the project file. For commercial projects, the file extension is .spc. These files are in Microsoft Access format, so they can be viewed, analyzed, and used through the Access interface. In addition, hourly load shapes may be exported to an LDA/LDZ file. To do this, select File→Export from the 8,760-hour graph. The result will be as shown in Figure 5-22.

Figure 5-22: Exporting 8,760 to File in LDA Format



5.7 Print Results

Results can be printed one page at a time or in batch. To print a single page, select the desired chart and select File→Print. To print the entire set of charts for a site, select File→Print All.

Appendix F

Listing of SITEPRO Annual Results

Not available electronically.

Appendix G

Descriptive Statistics for Variables Used In Realization Rate Model

Not available electronically.

Appendix H

Descriptive Statistics for Variables Used In Efficiency Choice Models

---

Not available electronically.

Appendix I

Information Relating to 1994 Program Year

Not available electronically.

Retroactive Waiver for Program Year 1994

Narrative on Retroactive Waiver for Program Year 1994

Tables E-2 and E-3 for Program Year 1994

Appendix J

Tables E-2 and E-3 for Program Year 1995

Not available electronically.

Appendix K

Table 6 for Program Year 1995

SAN DIEGO GAS &
M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY94 SECOND EARNING
FIRST YEAR LOAD IMPACT EVALUATION, I
Designated Unit of Measurement: LOAD IMPACTS PER PARTICIP

= Optional

				LOWER BOUND
1. Average Participant Group and Average Comaprison Group		**PART GRP**	**COMP GRP**	**PART GRP**
A. Pre-install usage:	Pre-install kW	na	na	
	Pre-install kWh	na	na	
	Base kW	na	na	
	Base kWh	na	na	
	Base kW/ designated unit of measurement	na	na	
	Base kWh/ designated unit of measurement	na	na	
B. Impact year usage:	Impact Yr kW	na	na	
	Impact Yr kWh	na	na	
	Impact Yr kW/designated unit	na	na	
	Impact Yr kWh/designated unit	na	na	
2. Average Net and Gross End Use Load Impacts		**AVG GROSS**	**AVG NET**	**AVG GROSS**
	A. i. Load Impacts - kW	8,469	4,977	7,804
	A. ii. Load Impacts - kWh	47,686,000	28,200,000	43,943,000
	B. i. Load Impacts/designated unit - kW	29.716	17.459	27.383
	B. ii. Load Impacts/designated unit - kWh	167,321	98,948	154,186
	C. i. a. % change in usage - Part Grp - kW			
	C. i. b. % change in usage - Part Grp - kWh			
	C. ii. a. % change in usage - Comp Grp - kW			
	C. ii. b. % change in usage - Comp Grp - kWh			
D. Realization Rate:	D.A. i. Load Impacts - kW, realization rate	1.1072	0.7535	1.0202
	D.A. ii. Load Impacts - kWh, realization rate	1.5175	1.0315	1.3984
	D.B. i. Load Impacts/designated unit - kW, real rate	1.1072	0.7535	1.0202
	D.B. ii. Load Impacts/designated unit - kWh, real rate	1.5175	1.0315	1.3984
3. Net-to-Gross Ratios		**RATIO**		**RATIO**
	A. i. Average Load Impacts - kW	0.588		0.289
	A. ii. Average Load Impacts - kWh	0.591		0.2908
	B. i. Avg Load Impacts/designated unit of measurement - kW	0.588		0.289
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.591		0.2908
	C. i. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kW			
	C. ii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kWh			
4. Designated Unit Intermediate Data		**PART GRP**	**COMP GRP**	**PART GRP**
	A. Pre-install average value	na	na	na
	B. Post-install average value	na	na	na
6. Measure Count Data		**NUMBER**		
	A. Number of measures installed by participants in Part Group	Attached		
	B. Number of measures installed by all program participants in the 12 months of the program year	Attached		
	C. Number of measures installed by Comp Group	na		
7. Market Segment Data		**SIC or CZ**	**PERCENT**	
	Distribution by 3 digit SIC - Commercial/Industrial	See Attached		
	Distribution by Weather Zone	Miramar	151	
		San Diego	101	

& ELECTRIC
;S CLAIM FOR AGRICULTURAL ENERGY MANAGEMENT SERVICES PROGRAM
NOVEMBER 1995, STUDY ID NO. 944
ANT FROM ALL PRACTICES AND MEASURES COMBINED.

5. A. 90% CONFIDENCE LEVEL			5. B. 80% CONFIDENCE LEVEL			
UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND
PART GRP	COMP GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP
AVG GROSS	AVG NET	AVG NET	AVG GROSS	AVG GROSS	AVG NET	AVG NET
9,134	2,499	7,505	7,952	8,986	3,001	6,928
51,429,000	13,874,000	42,526,000	44,772,000	50,600,000	17,005,000	39,254,000
32.049	8.590	26.328	27.9	31.532	10.528	24.303
180,456	48,682	149,214	157,098	177,544	59,666	137,736
1.1941	0.3783	1.1362	1.0395	1.1748	0.4544	1.0489
1.6366	0.5075	1.5555	1.4248	1.6102	0.622	1.4358
1.1941	0.3783	1.1362	1.0395	1.1748	0.4544	1.0489
1.6366	0.5075	1.5555	1.4248	1.6102	0.622	1.4358
RATIO			RATIO	RATIO		
0.886			0.354	0.818		
0.891			0.356	0.823		
0.886			0.354	0.818		
0.891			0.356	0.823		
PART GRP	COMP GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP
na	na	na	na	na	na	na
na	na	na	na	na	na	na

Appendix L

Table 7 for Program Year 1995

Table 7: Data Quality and Processing Documentation for 1995 Nonresidential New Construction Program First Year Load Impact Evaluation
March 1997
Study ID No. 971

7.A Overview Information
1. 1995 Nonresidential New Construction Program, Study ID number 971.
2. The program year is 1995. The Nonresidential New Construction is designed to induce builders to increase energy efficiency in construction beyond the levels required by Titles 20 and 24. The program offers informational and training workshops for builders, and provides incentives for the installation of demand-side management (DSM) measures. See Section 1.2 for a detailed program description.
3. The program is targeted primarily at interior lighting and HVAC end uses, although some measures affecting other end uses were incentivized in 1995. A variety of DSM measures are covered by the program, including high-efficiency lighting, high-efficiency cooling, VSDs for ventilation and pumping systems, and high efficiency motors.
4. The realization rate approach, a specific type of mixed engineering/statistical method, was used in this evaluation. This model relies on engineering estimates developed under two scenarios for both participants and nonparticipants: the reference scenario (e.g., minimal compliance with building and appliance energy efficiency standards); and an as-built scenario (with all program and non-program measures in place). Engineering estimates were developed using RER's SitePro software system. SitePro utilizes DOE-2 to model HVAC loads and well-tested engineering algorithms for estimating non-HVAC loads. The development of engineering estimates is detailed in Section 4. The realization rate model produces a set of adjustment coefficients (or adjustment functions) that translate SitePro engineering estimates into estimates consistent with observed energy usage and savings. These coefficients reflect the proportion of the engineering-based savings estimates actually realized in the form of reduced site usage. See Section 5 for a summary of the realization rate model specification.
5. In this analysis participants are defined as customers who participated in the 1995 Nonresidential New Construction Program. Nonparticipants are considered to be all sites undergoing new construction, major remodels or tenant improvements in 1995 that did not participate in the program.

Table 7 (continued): Data Quality and Processing Documentation for 1995 Nonresidential New Construction Program First Year Load Impact Evaluation March 1997 Study ID No. 971

6. The final analysis database consisted of the following numbers of sites:

Engineering Analysis: Made use of on-site survey data on 410 sites (252 participants and 158 nonparticipants). Estimates were developed on an hourly basis, then aggregated to a monthly level.

Realization Rate Analysis: Made use of engineering estimates and billing data on 204 participating and 145 nonparticipating sites with billing data matched to the surveyed site. Thirteen monthly observations were used for each site, but one observation was lost in the course of the autocorrelation correction.

Net-to-Gross Analysis: Made use of annual efficiency indices and cross-sectional data on 209 participating sites and 96 nonparticipating sites.

Refer to Section 2 for a detailed summary of participant and nonparticipant analysis samples.

7.B Database Management

1. The evaluation of the Nonresidential New Construction Program required several types of data. The integrated database for the evaluation is comprised of five components: (1) on-site survey data for participating and nonparticipating sites, (2) DOE-2 building simulations, (3) hourly weather data by CEC weather zone, (4) daily weather data by SDG&E weather zone, (5) consumption records, and (6) telephone survey data of participating and nonparticipating builders and developers. Figure 7.1 illustrates the relationship among these data elements.

2. The RER project team collected the on-site survey data, conducted the DOE-2 simulations, and conducted the telephone survey of participating and nonparticipating builders and developers. Hourly weather data by CEC weather zone and the daily weather data were provided by SDG&E. Section 3 describes the collection of on-site data, weather data, billing data and decision-maker survey data. Section 4 describes the development of engineering estimates.

3. The program database consisted of 285 distinct sites. Of these, 253 sites were ultimately subjected to the on-site survey. One of these sites was discarded from the analysis, leaving 252 participant sites to be covered by the engineering analysis. However, billing data matching the surveyed sites were available for 204 of these sites, so only these sites were covered by the realization rate analysis. The lack of appropriate billing data stemmed from the fact that some sites were covered by meters also covering

Table 7 (continued): Data Quality and Processing Documentation for 1995 Nonresidential New Construction Program First Year Load Impact Evaluation March 1997 Study ID No. 971

significantly more area (e.g., campus settings with large master meters). Decision-maker surveys were completed for 209 of the participating sites, and were available for the net-to-gross analysis. The nonparticipant frame for the on-site survey consisted of 527 sites for which building permits had been issued in 1994 or 1995. Of these, 115 were duplicate sites and 203 had not had new construction or major remodels or tenant improvements. This left 209 qualified sites. Of these, 51 refused to participate in the on-site survey. On-site surveys were completed for the remaining 158 nonparticipant sites. All of these sites were covered by the engineering analysis. Billing data matching the surveyed sites were available for 145 of these nonparticipating sites. Again, the unavailability of billing data traced to master metering. Decision-maker surveys were completed for 96 of the nonparticipant sites, thus allowing these sites to be included in the net-to-gross analysis.

4. Special emphasis was placed on the accurate identification of meters at the surveyed sites. Reconciliation of site areas and metered areas took place at five points during the project.

- First, accounts were aggregated to customer locations in the sample-design phase.
- Second, surveyors verified the account matching during the on-site visit. Changes in account numbers were recorded on the survey form.
- Third, for the sites for which the surveyors had complete billing information, they computed energy intensities while at the site. Intensities that are out of the "reasonable" range were investigated with the customer contact. Potential problem sites, or ones for which intensities could not be computed, were flagged for follow-up by the RER analysis team.
- Fourth, the billing information was reviewed by RER staff. Again, the intensities were reviewed and problems were flagged for follow-up with the SDG&E Project Manager.
- Finally, when the simulations were performed, the results were compared with the billing data. If the simulation and billing data differed substantially, and there appeared to be no problems with the survey data, these cases were reviewed further.

5. Not applicable.

Table 7 (continued): Data Quality and Processing Documentation for 1995 Nonresidential New Construction Program First Year Load Impact Evaluation
March 1997
Study ID No. 971

7.C Sampling
1. A census of both participants and nonparticipants was attempted. Of the 285 distinct participating sites, on-site surveys were completed for 253. The associated participant on-site survey response rate was 91%. The nonparticipant frame contained 209 qualified sites, 158 of which received on-site surveys. The nonparticipant on-site survey response was 76%. 2. Appendix A of the report contains a copy of the on-site survey instrument. Appendix B of the report contains copies of the participant and nonparticipant decision-maker survey instruments. Response rates for these surveys are presented above in item 1. Given the high response rates, non-response bias was not considered a major problem. 3. Appendix C contains a sample inventory report for the on-site survey. Appendix D presents frequencies for the decision-maker surveys. Appendix E provides a SitePro User Guide. Appendix F provides a listing of the SitePro results. Appendix G presents descriptive statistics for the variables used in the realization rate analysis. Appendix H presents descriptive statistics for the variables used in the net-to-gross analysis. Additional descriptive statistics for participants and nonparticipants are presented throughout the Report.
7.D Data Screening and Analysis
1. In this project, we did not attempt to screen out outliers per se, but large residuals were reviewed to identify data anomalies. In a few cases, consumption readings seemed to reflect partial occupancy of the site; these reading were omitted from the realization rate analysis. No observations were omitted from the efficiency (net-to-gross) analysis. There were no missing data from the on-site survey or from the decision-maker survey. Missing billing data caused some sites to be left out of the realization rate analysis, as explained above under 7B.3. Weather adjustment variables were included in the realization rate model. Setting these variables equal to 0 essentially weather-normalized the realization rates and the estimates of realized savings. 2. Not applicable. The analyses of gross and net savings relied on differences across sites, rather than changes in consumption. 3. See Section 7B.3. 4. Regression statistics for the realization rate analysis are presented in Table 5-1 and the results of the estimated efficiency equations are presented in Tables 6-3 through 6-5.

Table 7 (continued): Data Quality and Processing Documentation for 1995 Nonresidential New Construction Program First Year Load Impact Evaluation March 1997 Study ID No. 971

5. Realization rate analysis is presented in Section 5, with the rationale for the model specification detailed in Sections 5-2 and 5-3. The net-to-gross analysis is presented in Section 6. The rationale for the efficiency model specifications is presented in Section 6.4. Note the following:
   a. The realization rate model contains engineering estimates developed at the individual site level. These estimates take into account the factors that affect end-use consumption levels. The efficiency models include a variety of both site characteristics and decision-making factors.
   b. The realization rate model includes engineering estimates that reflect changes in consumption over time. In addition, it includes actual weather, which will also affect usage.
   c. Self-selection bias is addressed in the efficiency analysis. Two means of mitigating self-selection are used: the double Train/Goldberg Mills Ratio approach and the Hartman instrumental variables approach. See Section 6.4.
   d. No important factors were knowingly omitted from the analysis.
   e. The efficiency models presented in Section 6 are designed to estimate the net impacts of the program on efficiency levels.
6. This analysis did not address the issue of measurement error, except in the sense that the realization rate analysis reconciled engineering estimates of usage to actual billed consumption.
7. Autocorrelation, which is the correlation of the error term over time for individual sites, was found to be present in the realization rate analysis. This problem was mitigated with generalized least squares, a standard remedy. All realization rate models presented in the study correct for the presence of autocorrelation.
8. Heteroskedasticity was also found to present in the realization rate analysis. The error variance was found to be positively related to scale of the sites, as represented by square footage. Generalized least squares was used to mitigate the problem.
9. The issue of collinearity was addressed in this analysis through careful specification of interaction terms and through omission of some variables found to be highly collinear with others. Moreover, individual savings terms were aggregated with prior weights in some specifications in order to mitigate collinearity across program variables

Table 7 (continued): Data Quality and Processing Documentation for 1995 Nonresidential New Construction Program First Year Load Impact Evaluation March 1997 Study ID No. 971

10. Influential data points were identified by plotting regressors against residuals. No observations were omitted from the realization rate analysis, except as indicated above under 7D.1. No observations were omitted from the efficiency analysis on the basis of outlier analysis.

11. In the realization rate analysis, there were no missing data for regressors. For some sites, however, billing data associated with the specific surveyed area were unavailable. These cases were assigned missing consumption readings. They were thus not used to estimate realization rate model coefficients. Due to the lack of decision-maker survey information for some sites, these sites were omitted from the efficiency (net-to-gross) analysis.

12. Standard errors on estimated parameters are presented in results tables. Table 5-1 presents the t-statistics for each estimated parameter in the realization rate analysis. Confidence intervals for gross savings were based on Version 1. The standard error for combined savings was developed by combing the savings terms into a single composite variable, then estimating its overall standard error. Confidence intervals for net savings are based on the standard errors presented in Tables 6-3 through 6-5. Insofar as net-to-gross ratios are estimated by end-use, relative confidence intervals were constructed for three end-use groups and the weighted to develop a single relative confidence interval for whole building net savings.

7.E Data Interpretation And Application

1. Net Program impacts are calculated from the results of the realization rate analysis and the net-to-gross analysis (Option A).

2. Sections 5 and 6 detail the rationale for the realization rate model and the net-to gross analysis, respectively. More specifically, Section 5.2 summarizes the general rationale for the realization rate model, and Section 4.3 discusses specific realization rate model used in this study. Gross savings were defined as the estimated end-use realization rates times the corresponding engineering estimate of savings. This calculation was done for surveyed participants, then expanded to the total program on the basis of SDG&E's program estimates of savings for surveyed and non-surveyed sites. Section 6.3 discusses the application of the simple difference of differences approach to obtain end use estimates of net-to-gross ratios. The overall net-to-gross ratio was defined as the ratio of weighted average net savings to weighted average gross savings for the participants covered by this analysis.