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CHEUS

Commercial Hourly End Use Study

Status Report 1982-1985

Conservation and Solar Division
City Light Department

COMMERCIAL HOURLY END-USE STUDY

Status Report
1982-1985

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August 1986

Acknowledgments

There are several people who made major contributions to the production of this report and they deserve special thanks. Sam McJunkin and his staff deserve recognition for their efforts with the graphics. Abigail Tijerina and her staff contributed painstaking and meticulous attention to typing and proofreading the text. Tom Sadowski was particularly helpful in the time-consuming review of the initial drafts. And, it was Ed Holt's valuable support and patience that made completion of this report possible.

COMMERCIAL HOURLY END-USE STUDY STATUS REPORT 1982-85

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Chapter 1

EXECUTIVE SUMMARY

Introduction

Until recently, relatively little information existed on the energy loads of commercial buildings. To accomplish objectives in conservation program planning and forecasting, Seattle City Light (City Light) began in 1982 a comprehensive research project on energy use and conservation in commercial buildings--the Commercial Hourly End-Use Study (CHEUS). Data from the study will support City Light's efforts in designing programs and policies, and predicting the impact of these and other factors on future electricity demand. This status report describes the progression of events of CHEUS from its inception in 1982 to the end of 1985. Included are the preliminary results of the hourly load data and conservation analysis conducted on each building during this period.

Chapter 2: Overview of Project

The CHEUS study began in 1982 with the selection of two buildings. The receipt of Bonneville Power Administration (BPA) grant funds allowed City Light to expand the number of monitored buildings to eight--a sample consisting of two office buildings, two retail stores, two grocery stores, and two restaurants. By the end of 1983, hourly end-use data collection was underway. The conservation analysis of these buildings was completed in 1984. The process for installing selected energy-saving measures started mid-year 1985 and ended in early 1986. Monitoring of the buildings will continue until fall 1987. Completion of the analysis on the impact of the conservation improvements is anticipated by mid-1988.

Chapter 3: Building and Equipment Selection

Five criteria were developed for the selection of study buildings, ranging from single-occupancy use to easy access to the building and the electrical services. Using these, two buildings were selected for the field test of three alternative methods of measuring electrical loads at the hourly level. The first method used an inexpensive, single-channel, strip chart recorder on the heating load, and derived an hourly lighting load profile from the one-time measurements of the lighting circuits and from an estimated lighting schedule. The second method utilized two strip chart recorders, one for heating and one for lighting. In the third method, a microprocessor data logger system was developed to record and store instantaneous voltage and current measurements.

The results of the field test showed that the data logger system was the most accurate and reliable method for measuring multiple electrical loads at the hourly level. Data loggers were installed in the six additional buildings that were selected on the basis of the same criteria developed for the first two buildings.

Chapter 4: Hourly End-Use Load Analysis

The hourly end-use analysis indicated that lighting was the largest electrical end use for the retail stores. The 1985 annual electrical consumption for the all-electric retail #1 was 23.8 kwh/sq.ft. and lighting was 67 percent of this total. In the gas-heated retail #2, lighting was 90 percent of the 1985 annual consumption of 17.1 kwh/sq.ft.

In the two all-electric office buildings, the largest end-use load was heating, ventilation and cooling (HVAC). In office #1, HVAC accounted for 48 percent of the annual average of 15.1 kwh/sq.ft. in 1985. In office #2, 47 percent of the 1985 annual consumption of 17.1 kwh/sq.ft. was for the HVAC system.

Refrigeration was the largest electrical end use in the grocery stores. The all-electric grocery #1 consumed 61.0 kwh/sq.ft. in 1985 and refrigeration accounted for 36 percent of this total. In the gas-heated grocery #2, the average 1985 annual consumption level was 83.9 kwh/sq.ft. and refrigeration accounted for 63 percent. This store had more refrigerated space than grocery #1.

In both of the study restaurants, the food processing equipment, the largest electrical end-use load, accounted for 48 percent of the electrical energy usage. The 1985 annual consumption was 115.5 kwh/sq.ft. in restaurant #1 (fast food) and 106.0 kwh/sq.ft. in restaurant #2 (24-hour coffee shop). Both restaurants used natural gas for cooking and heating.

Chapter 5: Conservation Analysis

The results of the conservation analysis of the two office buildings suggest that: (1) office buildings may consume less energy per square foot than was estimated before the study began, (2) recommended office building conservation measures will more likely be HVAC and lighting control strategies than building shell improvements, and (3) the potential for energy savings may be greater in lighting use than in heating consumption.

The analysis of conservation potential in retail buildings suggests that: (1) retail buildings may consume more energy for lighting than was estimated before the study began, (2) recommended retail store conservation measures will more likely be HVAC and lighting control strategies than building shell improvements, and (3) the magnitude of the savings may be less than was before the study began. However, due to lower estimated costs, savings with higher economic returns may be available.

The insights gained from the conservation analysis of the grocery stores suggest that: (1) lighting strategies, including delamping, are likely electrical conservation measures for gas-heated stores; (2) HVAC-related strategies, including a heat recovery system with controls, are possible conservation measures in an all-electric grocery store; and (3) greater savings may be expected from grocery stores with greater energy consumption.

The conservation analysis of the two restaurants suggests that electrical conservation opportunities in restaurants similar to the study buildings (fast food and 24-hour coffee shops) may be limited. For these two buildings, outdoor lighting strategies achieved the greatest amount of electrical energy savings.

Chapter 6: Installation of Retrofits

City Light received a grant in 1985 from Bonneville to implement the conservation measures specified in the conservation analysis of the study buildings. By October 1985, seven of the eight building owners had agreed to install the specified energy improvements and to implement the specified operation and maintenance improvements. Owners of one building declined to participate due to sale and permanent closure of the facility. A full report on the experience and lessons learned is available in a separate document entitled Installation of Energy Conservation Measures in Commercial Buildings (City Light, 1986), noted in Chapter 8, Bibliography.

Chapter 7: Analysis Agenda

Future analysis of the CHEUS data will include individual and building sector analysis. Individual building analysis will cover additional studies to characterize energy use, assess conservation potential, and evaluate the conservation load reductions. Building sector analysis will involve the use of data available from other commercial studies conducted in the City Light service area to expand the findings from the CHEUS work. Modification of the agenda is anticipated as work plans are developed and as additional research becomes available.

Chapter 8: Annotated Bibliography for CHEUS Products

An annotated bibliography of reports and other products that have been written or created during the period from 1982 to mid-1986 has been developed.

Seven reports covering topics from the selection of the buildings to the audit reports on the study building are related to the end-use load monitoring. An additional seven reports cover topics related to the simulation work. Other CHEUS products include monthly summary statistics on the end-use loads for each building, graphic representatives of these end-use shares and profiles, and the participation agreements with the building owners for the conservation retrofits. Five publications involving CHEUS data include articles and abstracts published by the Electric Power Research Institute, the Bonneville Power Administration, and the American Society for Heating, Refrigeration and Air-Conditioning Engineers.

Appendices

Appendix A includes the diagrams for the buildings, the summary data sheets on each building's characteristics and energy consumption, and the monthly summary statistics for each end-use load monitored. Appendix B contains the prioritized list of conservation strategies analyzed for each building. Appendix C is a copy of the participation agreement with building owners developed for the installation of selected conservation measures.

Chapter 2

OVERVIEW OF PROJECT

2.1 Introduction

The increasing availability and use of end-use load profiles in conservation planning and load forecasting has created a demand for understanding customer behavior at the end-use level. Until recently, relatively little data existed on the energy loads of commercial buildings. Information on the periods of time that consumption occurs, the amount of electricity required to operate various pieces of equipment, and other related factors that explain consumption patterns were lacking for commercial customers. To accomplish objectives in conservation program planning and fore-casting, City Light began in 1982 a comprehensive research project on energy use and conservation in commercial buildings. The data from the CHEUS will provide support to City Light's efforts in designing programs and policies, and predicting the impact of these and other factors on future electricity demand.

2.2 Project Objectives

The Commercial Hourly End-Use Study had two major purposes. First, the project provided an opportunity to test strategies for measuring end-use loads in commercial buildings. Once a cost-effective procedure for collecting hourly end-use load data was established, measurement of electrical loads data was undertaken in a small sample of buildings. The second major purpose was the development of City Light's capability to analyze the conservation potential of the selected buildings. This work involved auditing the structures, utilizing load simulation models, and developing estimates of load reductions and changes in load shapes due to conservation measures.

To serve these purposes, the following objectives were developed for the CHEUS:

a. To describe energy consumption by end use and by time for a variety of commercial building types.

b. To identify cost-effective conservation strategies for each building type.

c. To implement conservation strategies in a sample of commercial buildings and measure subsequent performance.

d. To determine how variations in building characteristics and occupant usage patterns affect conservation potential.

2.3 Project Schedule

The CHEUS evolved over time due to the experimental nature of the effort. The steps of the project's development can be traced over the years. The following descriptions highlight the milestones completed each year, beginning in 1982. Figure 2.1 displays the project's actual time line.

2.3.1 1982 Activities

The original scope of work for the project was drafted by Michael Baker, then of the City Energy Office, in late 1981. In early 1982, City Light reviewed the scope of work. The project subsequently began as a joint effort between the Energy Resources Planning and Management Division and the Conservation and Solar Division. A Request for Proposal was issued in April and a consultant contract was signed in August to carry out the scope of work.

By the end of the year, two buildings for the field test of the different load measurement methods had been selected and measurement plans for instrumentation developed. A microprocessor-based data logger system was assembled using commercially available components for collecting a continuous hourly record of end-use loads. Also, alternative load measurement methods were developed using strip chart recorders and load estimation techniques based on one-time measurements of end-use loads. The receipt of BPA grant funds in late 1982 allowed City Light to expand the number of monitored buildings. The six additional buildings were selected such that the eight-building sample contained two office buildings, two retail stores, two grocery stores, and two restaurants.

For the simulation of these eight buildings, DOE 2.1A was selected and installed at the University of Washington's Academic Computing Center. Audits of the two field test sites were completed and procedures for the analysis of the conservation improvements were designed by the end of the year.

Major decisions reached in 1982 included selecting the eight buildings for study, defining the end-use loads to measure, selecting a computer simulation model, and designing the various techniques of load measurement and conservation strategy analysis.

FIGURE 2.1

PROJECT TIME LINE
COMMERCIAL HOURLY END-USE STUDY
1982-1986

1982 JAN	
April	RFP ISSUED
Aug	CONSULTANT HIRED (Math Sciences Northwest)
Sept	TWO BUILDINGS SELECTED
Oct	BPA GRANT - 6-BLDG EXPANSION
1983 JAN	
Feb	EQUIPMENT INSTALLED 2 FIELD TEST SITES
April	BLDGS 3, 4, 5 INSTRUMENTED
July	BLDGS 6 and 7 INSTRUMENTED
Aug	BLDG 8 INSTRUMENTED
Oct	TWO BUILDING SIMULATIONS COMPLETED
Dec	NEW CONSULTANT HIRED (United Industries Corp.)
1984 JAN	
Mar	FIELD TEST REPORT COMPLETED
	DATA VERIFICATION
July	DATA BACKLOG ELIMINATED
	DATA EDITING
Dec	BUILDING SIMULATIONS COMPLETED (Bldgs 3, 5, 6, 7, 8)
1985 JAN	BPA GRANT-RETROFITS
Feb	FINAL BUILDING 4 SIMULATION COMPLETED
May	RETROFIT RFP ISSUED
July	CONSULTANT HIRED (Seton, Johnson and Odell)
Oct	7 BUILDING OWNER AGREEMENTS SIGNED
Nov	BUILDING 5 DECLINES PARTICIPATION
Dec	RETROFIT INSTALLATIONS BEGIN
1986 JAN	
May	RETROFIT INSTALLATIONS COMPLETED
April	MONITORING CONTINUES

2.3.2 1983 Activities

A field test of the three alternative load measurement techniques was completed in early 1983, along with the energy conservation analysis of the two field test buildings. The field test results indicated that the microprocessor method was the most accurate and reliable method for measuring hourly loads at the end-use level. By the end of the summer, all eight buildings were instrumented with data logger systems and data collection was underway.

In the second half of 1983, considerable effort was devoted to the development of data processing procedures at the University of Washington's Academic Computing Center. Data storage and retrieval procedures were designed and tested. Procedures to read, graph, and report on incoming data were developed.

In addition, data processing tools for working with the DOE 2.1A simulation models were developed. This computer simulation program was modified to extract hourly end-use savings during City Light's defined periods of peak, intermediate, and base loads.

A life-cycle cost program that uses the hourly energy savings was designed to incorporate City Light's methodology for incorporating estimates of the value of energy into the analysis of conservation. Also, a program was developed to manage the many computer-related tasks of the simulation modeling, such as storing and maintaining a directory of building descriptions, submitting batch jobs, and tracking output.

One major decision reached in 1983 was that the alternative load measurement methods were unreliable based on the results of the field test. On a per-building basis, these alternative methods were less expensive, permitting the monitoring of more buildings within a limited budget. With the selection of the most accurate and reliable, but most expensive microprocessor method, the project shifted from a large scale end-use metering study to a case study project to support conservation planning. Rather than instrument a large sample of buildings, as originally planned, the focus of the study became the conservation strategy analysis and assessment of the retrofit savings in the eight buildings. This new direction changed the project to a conservation study and another consultant was hired to continue the study under the new focus.

2.3.3 1984 Activities

The consultant change experienced in late 1983 resulted in a backlog of the hourly end-use data. Also, a few of the data logger systems were malfunctioning. The major effort of the first half of 1984 consisted of eliminating the backlog of data, developing routine data collection and verification procedures, repairing the malfunctioning equipment, and establishing equipment maintenance procedures.

Preliminary checks on the quality of data were conducted on the available data. Editing was necessary for every building's data set. By the end of the year, five of the eight data sets were corrected for equipment calibration factors, adjusted for Daylight Saving Time, and checked for consistency (building total equals the sum of the end uses).

The second half of 1984 also involved conducting energy audits and conservation analysis. In preparation for the conservation analysis, the life-cycle cost program developed in 1983 was tested and updated by September 1984. Since hourly end-use load data were used as input in the simulation model, conservation analysis on each building was conducted only after the data editing effort for that building was completed. Conservation analysis for five of the six remaining buildings was conducted by the end of the year.

The major decisions made in 1984 involved completing the report on the field test results, determining the quality levels for accepting the data received to date, and agreeing on the cost-effective conservation measures for each building analyzed.

2.3.4 1985 Activities

In early 1985, data editing was completed on the three remaining data sets and the conservation analysis of the eighth building was conducted. Routine data collection procedures permitted the efficient handling of the 90,000 hourly end-use data values processed each month from the eight buildings. A reporting system for displaying the monthly, weekly, and daily loads was developed, which included use of the data on personal computers. Dissemination of the study's findings City Light staff and administrators was started.

A grant from BPA for funding installation of the conservation measures was received in early 1985. A Request for Proposals was issued in April to hire a technical consultant to assist with the solicitation of building owners' participation and to oversee the installation of the measures. A consultant was hired in July, building owner agreements were obtained by October, and installations were underway by December.

In addition, a conservation analysis was conducted on two more buildings representing different building types than the original eight. These included a warehouse and a service station. This analysis provided energy-saving estimates for planning City Light conservation programs.

Major decisions made in 1985 included hiring a technical consultant to provide support during the process of installation of conservation measures, negotiating the agreements for installing the measures with the building owners, and selecting additional buildings for conservation analysis.

2.3.5 1986 Activities

Retrofit installations were completed by June 1986. Routine data collection will continue until August 1987, providing one year of data after the installation of the conservation measures. In preparation for the pre-/post-comparison, enhancements to the computer simulation program were made in early 1986 (such as updating the weather files used by the model). Analysis of the impact of the conservation measures is anticipated to begin by year end.

2.3.6 1987 Activities

The data logger equipment will be removed in fall 1987. Completion of the impact analysis of the conservation improvements is anticipated by mid-1988.

2.4 Project Staff

The success of this project depended upon the dedication and determination of many individuals. The principal staff members consisted of City Light employees, and engineering and computer programming consultants. The key members of the project are presented below in chronological order:

1982 - Project Managers:

Michael Baker, Seattle Energy Office and Conservation Division, City Light
Paul Reiter, Load Forecasting, City Light

Prime Engineering Consultant:
Gary Roth, Mathematical Sciences Northwest, Inc. (MSNW)

Consultant Subcontractors:
Perry Lovelace, Bouillon, Christofferson, and Schairer (BCS) (building audits)
Marc Schuldt, United Industries Corporation, Inc. (simulation)
Larry Palmiter, Ecotope, Inc. (measurement)
Mimi Sheridan, Hall and Associates (data collection)

Computer Programming:
Al Williams, Academic Computing Center (ACC), University of Washington
Ric Johnston, ACC

1983 - Project Managers:

Conservation Division, City Light
Michael Baker - until May 1983
Gary Quarfoth - until September 1983
Ed Holt - until January 1984

Load Forecasting, City Light
Paul Reiter - until December 1983

Prime Engineering Consultant:
Gary Roth, MSNW

Subcontractors same as 1982 with the addition of:
Henry Romer, Romer and Associates.

Computer Programming same as 1982 with the additions of:
Andy Vaughan, ACC
Dolly Sampson, ACC

1984 - Project Manager:

Colleen Cleary, Conservation and Solar Division, City Light

Prime Engineering Consultant:
Marc Schuldt, UIC
Staff: Laura Caldwell
Steve Crowl
Steve Scott
Lynn Qualmann

Subcontractors:
Mimi Sheridan, Hall and Associates
Staff: Leslie Rankin

Michael Evans, Evans and Associates (equipment repairs)

Computer Programming same as 1982

1985 - Project Manager same as 1984

Conservation Technical Support Staff, City Light
Barbara Crimmin
Javad Maadanian
John Songer

Prime Engineering Consultant same as 1984

Technical Consultant for Installation:
Glen Odell, Seton, Johnson and Odell (SJO)
Staff: Steve Kind

Subconsultants:
Larry Atkinson, Lee and Atkinson (electrical engineer)
Carolyn Uhorn, Futura Enterprises (photo documentation)

Computer Programming same as 1982 with the addition of:
Dolly Sampson, ACC

In addition to the efforts of these key staff members, the project received considerable support from the following individuals over the course of the study:

Ted Allstead, Meter Lab, City Light
Ellen Blackwood, Conservation, City Light
Ben Chan, Conservation, City Light
Ted Coates, Energy Resources Planning and Management (ERPM), City Light
Pat Dadosio, Conservation, City Light
Ted Elmer, ERPM, City Light
Ann Emigh, Conservation, City Light
David Freeh, City Light Photographer, City Light
Gil Haselberger, Conservation, City Light
Christine Lamb, Graphics, City Light
Beverlee Little-Strong, Conservation, City Light
Dick Lundquist, ERPM, City Light
Ken Mathews, Conservation, City Light
Sam McJunkin, Graphics, City Light
Carlos Mussa, Conservation, City Light
Steve Pool, Conservation, City Light
Abigail Tijerina, Word Processing, City Light
Harry Wall, Conservation, City Light
Mike Warwick, BPA
Carin Weiss, Conservation, City Light
Al Wilson, ERPM, City Light
Phil Windell, BPA
R&D Committee, City Light
Tim Croll
Larry Gunn
Malcolm Macdonald
Tom McArthur
Tom Rockey
Shani Taha, Chairperson
Al Yamagiwa
R&D Support Staff, City Light
David Docter
Suzanne Machette

2.5 Project Budget

The following table summarizes the CHEUS's estimated expenditures over the past five years.

Table 2.1

Commercial Hourly End-Use Study
Estimated Expenditures 1982-1986
(Nominal Dollars)

	1982	1983	1984	1985	1986	Five-Year Total
BPA						
Consultant	150,000			50,000		200,000
Retrofits				192,117		192,117
BPA Subtotal	150,000			242,117		392,117
City Light						
Consultant						
Cons.(R&D)	102,924	151,104	61,985	60,000	37,696	413,709
Data Process*	65,000		68,785	50,777	67,712	252,274
Labor**			23,209	49,476	46,891	111,909
Other			600	137	537	1,494
City Light Subtotal	167,924	151,104	154,579	152,943	152,836	779,386
GRAND TOTAL	317,924	151,104	154,579	395,060	152,836	$1,171,503

*Includes software development and consultant time. Funds encumbered in late 1982 were spent in 1982 and 1983.

**City Light labor was not available for 1982 and 1983 expenditures.

2.6 Importance of the Project

With the support of BPA and City Light R&D funding, the CHEUS has served as the lead project in the Northwest for the collection of hourly load data at the end-use level in commercial buildings. At the time of its inception, the study took a very innovative approach to the difficult problem of end-use metering and pursued a solution in a thorough and systematic manner. The information gathered can begin to address the many questions City Light and others have on commercial building loads. The lessons learned from the CHEUS work have paved the way for other utilities undertaking end-use monitoring studies.

2.6.1 End-Use Load and Conservation Assessment Program (ELCAP)

In 1984 BPA began several research projects involving monitoring of buildings in the residential and commercial sectors. The insights gained from the CHEUS project were applied to the BPA effort and a new direction in end-use metering emerged. Through the development efforts of Battelle's Pacific Northwest Laboratory, the CHEUS approach of using a multichannel, digital instrument was developed further. As a result, several end-use monitoring efforts sponsored by BPA are now in progress.

One particular BPA study will in turn benefit City Light understanding of commercial buildings in its service area. The BPA study involves the end-use monitoring of a stratified random sample of commercial buildings in the City of Seattle; approximately 170 were constructed before 1980 and 30 were constructed since the 1980 adoption of the Seattle Energy Code. As of the end of 1985, access agreements have been obtained and installation of the monitoring equipment is progressing well.

The ELCAP data from these 200 buildings will allow City Light to expand its understanding of consumption patterns from the eight case studies of CHEUS to a larger sample with a greater variety of buildings. The early analysis of the eight buildings in CHEUS has provided a preview of the potential research findings that may emerge when data from 200 buildings become available. Presentations of CHEUS analyses have been given at several BPA-sponsored ELCAP workshops in 1985.

2.6.2 Electric Power Research Institute (EPRI)

EPRI has recently undertaken a major effort to help utilities develop improved estimates of commercial end-use load shapes. One purpose of the EPRI project is to facilitate the transfer of experience among utilities that are conducting or are contemplating commercial end-use metering projects. In January 1985, EPRI sponsored a workshop in Seattle to exchange ideas, techniques, and lessons of experience regarding end-use metering. City Light's CHEUS effort was the lead project in that workshop. Data from two buildings provided insights on the use of DOE 2.1 simulation models and a statistical prorate technique to estimate end-use load shapes. Results of this analysis were published in a January 1986 EPRI report (see BIBLIOGRAPHY for a complete listing).

2.6.3 Dissemination of Data Within City Light

In addition to Conservation Planning staff, other City Light staff members from Load Forecasting, Commercial Auditing, Rates and Consumer Research, and Commercial Customer Technical Advisory Services are interested in the study's findings. The first step in disseminating information from the CHEUS project within City Light was the development of a slide show covering the overall objectives and the steps of the research. In 1984 and 1985 this presentation was given to over 250 City Light staff members, including field personnel, managers, and analysts involved with commercial customers.

In addition, the data have been made available to City Light's staff of Load Forecasting, Conservation Program Evaluation, Conservation Policy Development, and Commercial Building Auditing sections. An example of data sharing has involved preliminary reports of end-use load consumption by building type. While use of the data has really just begun, research findings have already become integrated in many energy-related decisions. City Light has used the data in developing estimates for a commercial conservation pilot program, estimating the value of energy savings from this pilot program, developing projections for a demonstration retrofits program for industrial customers, and in developing long- and short-range forecasts for the commercial sector. As City Light analysts and others become aware of the value of the data, and as the tools for easy data access are developed, the data will serve a variety of purposes in assisting City Light's decision makers in the future.

Chapter 3

BUILDING AND EQUIPMENT SELECTION

3.1 The Field Test

3.1.1 The Purpose

The CHEUS began with a field test of equipment and procedures for measuring end-use loads in commercial buildings. The primary purpose of testing the data collection effort was to develop a cost-effective procedure for measuring energy demand by end-use load on a per-hour basis. Different pieces of equipment were installed to test alternative ways of collecting hourly end-use load data on two buildings. The field test provided an opportunity to learn and document a practical procedure for the collection of hourly end-use data in commercial buildings, after each of the measurement methods was evaluated for accuracy and cost.

3.1.2 Building Selection Criteria

The two commercial building types selected for the field test were an office building and a dry goods retail building. Three steps were developed to determine the selection of these buildings. First, the building selection criteria were developed. Second, building managers were contacted and the candidate buildings were inspected. Third, the buildings were evaluated according to the selection criteria. If a building did not fulfill a criterion, it was dropped as a study candidate. After building selection, measurement plans for each building were developed, which included identification of the end-use loads, assignment of major equipment and individual circuits to particular end-use loads, and identification of measurement points and wiring layout.

The five selection criteria that were applied to the candidate buildings are listed below in order of importance in determining the final selection:

a. The building should have a single-occupancy use.

b. Building managers should have a level of interest and availability to ensure cooperation throughout the study.

c. Building documentation such as mechanical and electrical drawings should be available.

d. End-use loads should be separated so that a particular wire only serves one end-use load or partial load.

e. Access to building and electrical services should be possible.

In the two buildings selected, management and pertinent staff members were cooperative and enthusiastic about being involved in the project. In the retail store, the separation of end-use loads was considered good, as was the potential for after-hours access. In the office building, the separation of end-use loads was more complex and it was more difficult to access the building after hours because the acquisition of a key was necessary.

3.1.3 Description of the Two Field Test Buildings

3.1.3.1 The Retail Building

The dry goods retail facility specializes in drug and sundry items and is open for business 77 hours a week. The average number of customers per hour is 44. Built in 1973, the building is constructed of concrete block on a concrete slab on grade, with a built-up roof. The total floor area is 22,326 sq.ft. Of this space, 82 percent is sales area, 11 percent is storage, and 7 percent is office. Glass represents 3.4 percent of the gross wall area. The HVAC system is comprised of a single-zone heating and cooling system with electric resistance heaters and direct expansion cooling. The system is controlled with thermostats set at 68° F for heating and 72° F for cooling. Sales area lighting is primarily provided by 8-foot fluorescent fixtures, which were added in late 1984 to replace the original 400-watt mercury vapor fixtures. Office lighting is fluorescent with some incandescent spots. Exterior lighting is fluorescent.

3.1.3.2 The Office Building

The office building is six stories tall and contains a variety of office operations. It is typically occupied 50 hours a week, 8 a.m. to 6 p.m., Monday through Friday. The average occupancy level is 400 people. Built in 1976, the building was constructed in two rectangular sections, one four stories and the other six. The structure was built on a concrete slab with precast concrete walls. The total floor area is 89,550 sq.ft. Of the gross wall area, 47 percent is glass. Heating and cooling is provided by 91 hydronic heat pumps that operate 24 hours a day. The ventilation system, which tempers outside air with a recovery system and a resistance duct heater, operates on a time clock 15 hours a week on weekdays only. Lighting is predominantly fluorescent with some incandescent spots.

3.1.4 Measurement Methods

The goal of the field tests was to establish a procedure for end-use measurement that was cost effective, while maintaining a reasonable level of accuracy. Three alternative methods were tested in both the selected buildings.

3.1.4.1 Method 1 - Strip Chart Recorder and Load Estimation

In measurement Method 1, a $300 Rustrack model 288 single-channel strip chart recorder was used on the heating load. Current in the electrical circuits was measured using current transducers. These sensors are referred to as current transformers since they use transformer coupling to detect the magnitude of current in a wire. The AC signal was reduced to produce a current measurement that was within the range read by the strip chart recorder. The current measurements were instantaneously recorded onto a roll of chart paper at four-second intervals. This created a continuous tracing of consumption and time. The chart speed was regulated by the tractor paper roller which was set at one-inch per hour; thus a 63-foot roll of chart paper collected a month's worth of data.

The lighting load in Method 1 was obtained from a one-time measurement of the lighting circuits and an estimated lighting schedule. Since the schedule assumed an on/off nature for lights, an hourly record for the light end use was estimated.

3.1.4.2 Method 2 - Two Strip Chart Records

In measurement Method 2, two strip chart recorders were used, one for the heating and one for the lighting loads.

3.1.4.3 Method 3 - Microcomputer Data Logger

Measurement Method 3 used a specially developed data logger system to record and store instantaneous voltage and current measurements. The logger system used a LSI-11 microprocessor developed by Digital Equipment Corporation. The hardware setup consisted of a collection of modules that included a central processor and memory, printed circuit cards, input and output cards, data terminal, and mass storage media. These board-level components were assembled into a system to collect the end-use load data. A power supply and card cage assembly provided a data and power bus into which various electronic cards were inserted. The microprocessor card provided the system intelligence. The multifunction card provided 32 K bytes of random access memory, two serial data ports, and the system start-up boot program. One serial port drove the digital tape cassette for mass storage, and the other was used to drive a terminal for local operations during installation. An analog-to-digital converter with a channel multiplexer was used to input sensory data. An expansion card increased the multiplexed inputs to 32 channels. Current in the electrical circuits was measured using the same current transformers used with the strip chart records in Methods 1 and 2.

Some unique features made this microcomputer system especially suited for collection of end-use load data. First, a battery-powered clock and calendar ensured that the correct time was available. After a power failure, the system recovered to the correct date and time rather than continuing from where it originally left off. As a result, correct hourly data could be acquired and the duration of a power failure could be traced and documented. Second, the large amount of active memory space allowed a complex program to be executed. Each minute the signals were sampled and stored in a memory buffer. Each hour the measurements of effective voltage and effective current were multiplied together with one-time measurements of power factor to calculate the average energy demand per hour. The hourly averages were then written to a magnetic tape every hour to prevent loss of information due to power failure. Tape capacity was approximately one month of data.

Data reliability was enhanced by the creation of individual data files for every day of the month; data files were opened for only a short time once an hour. An entire month's worth of data could be destroyed if a file was open when a power failure occurred. To avoid this sort of substantial loss of data, single files only contained one day's worth of data. Therefore, if a file was lost, only one day was lost.

Three kinds of measurements that characterize energy consumption were made with this system. Three channels measured the voltage of input circuits. Eight to 10 channels measured main circuit panels that covered the major equipment loads, and two to four channels measured smaller equipment. The kilowatt end-use load channels were computed from the volt and appropriate amperage channels. Approximately 15 channels were needed to characterize each building's four or five major end-use loads. In the retail building, lighting, heating, cooling, ventilation, and other (outlets and hot water) end-use loads were monitored. In the office building, the lighting, heating, cooling, ventilation, heat pumps, and other (outlets, elevator, and hot water) end-use loads were monitored.

3.1.5 Equipment Installation and Costs

The monitoring equipment for each of the three measurement methods was installed simultaneously in the two buildings. In each building, two strip chart recorders and one microprocessor were installed as well as the necessary sensors and wiring. Three site visits were required to complete the installation. The following 10 steps were associated with the equipment installation:

1. Select location and mount microprocessor box;
2. Obtain AC power;
3. Identify breakers to have sensors installed;
4. Run cables to microprocessor;
5. Make one-time measurements;
6. Attach sensors and secure for later identification;
7. Set up strip chart recorders;
8. Run cable to strip chart recorders;
9. Install sensors; and
10. Verify calibration and operation.

The original installation scheme called for one-time measurements to calibrate the individual microcomputer channels and strip chart recorders. This scheme was not sufficient because not all of the equipment that was monitored was "on" at the time of the installation. Thus, the procedure was modified to precalibrate the sensors and microcomputer channels prior to installation. Subsequently, on-site calibrations became necessary to ensure the quality of the microprocessor data values. Nearly every channel required calibration.

Table 3.1 is a breakdown of actual costs for the three measurement methods used in the field test in 1983.

Table 3.1

Summary of Measurement Costs Per Building - Field Test
(1983 Dollars)

1. Estimation and one strip chart recorder

Equipment	$ 427
Labor	6,570
TOTAL	$ 6,979

2. Two strip chart recorders

Equipment	$ 1,076
Labor	11,640*
TOTAL	$12,716

3. Microprocessor system (4 to 6 end-use loads)

Equipment	$ 7,668
Labor	7,690
TOTAL	$15,358

*Includes cost of making strip chart recorder measurements machine readable.

3.1.6 Results of the Comparison

The period of data collection went from hour one of February 1, 1983 to hour 24 of March 15, 1983, for a total of 1,056 hours, or six weeks, of hourly end-use load data. Data acquired during the test period were examined so that the performance of each measurement method could be tested.

To evaluate the performance of three different measurement methods, City Light's billing meter was used as the primary reference of energy consumption for the entire building. First, the accuracy of the microprocessor (Method 3) measurement of total building consumption was assessed using the City Light meter as a standard; then the accuracy of the strip chart recorder used in Methods 1 and 2 for the heating and lighting loads was assessed using the microprocessor as a standard. The accuracy of the estimation technique for lighting load used in Method 1 was also assessed using the microprocessor as a standard. The results of these comparisons are described below.

3.1.6.1 Accuracy of the Microprocessor

The three major sources of error for the microprocessor were caused by calibration, power factor determination, and omission errors. While calibration of the system took place prior to the installation, verification in the field was required for accuracy. The determination of power factor was identified as a potential source of measurement error, but no estimate of the magnitude of this error could be made from the field test data. The omission errors were due to two problems in measuring end-use loads in the office building. First, it was only possible to measure one phase of the three-phase circuits. Since the phases were not balanced, the estimates from only one phase resulted in a discrepancy in the end-use load measurements. Second, it was not possible to directly measure the loads on all of the floors of the office building. The power to the microprocessor on the third floor could not be shut off to allow the data logger to be connected because the processor was in use 24 hours a day.

The results of the microprocessor error analysis determined that the system had an accuracy level of ±6 percent or better during the field test in measuring total building load when all appropriate circuits were properly monitored. Hourly values of individual end-use loads were estimated to have an average accuracy level of ±9 percent. Loads that fluctuated widely such as heating, and loads of short duration such as elevators, had the greatest potential for measurement error due to the uncertainty of the calibration. The projected accuracy level of the microprocessor for the hourly values was within 5 percent when more rigorous calibration and monitoring techniques were applied.

3.1.6.2 Accuracy of the Strip Chart Recorder

A number of problems that were encountered with the strip chart recorder used in measurement Methods 1 and 2 affected its accuracy level. The paper speed of the device was unreliable, and at the end of the month, the charts were off by as much as four days. When the recorders were adjusted to correct for this time discrepancy, the drive sprocket tore the chart paper. A complete loss of data would have resulted, but by using the microprocessor measurements the time base was restored for the strip chart recorder. This permitted the accuracy of these recordings to be compared with the microprocessor measurements.

The three largest error sources for the strip chart recorder were calibration, voltage measurement, and omission errors. Three of the four recorders were not calibrated properly and consistently read high. They had been calibrated at the time of the installation using the previously taken one-time measurements of circuits. New one-time measurements should have been taken at the time of installation. Building voltage used in the strip chart recording of current was based upon a one-time voltage measurement; hence, its value was held constant throughout the field test period. However, the microprocessor hourly data indicated that there were hourly fluctuations in voltage measurements. Such variations could have led to a measurement error of ±14 percent in the retail store, and ±6 percent in the office building. Another major source for the measurement error was the monitoring of one phase of three-phase circuits.

The accuracy of the strip chart measurements of the hourly heating and lighting end-use loads, using the microprocessor-measured values as a measurement standard, was determined to be within ±21 to ±32 percent of the measured loads in the field test. If steps were taken to minimize measurement errors noted above, the projected accuracy level of this strip chart recorder would have been 19 percent. Given this projected accuracy level and the unreliability of the equipment, strip chart recorders were not recommended for application in future buildings.

3.1.6.3 Accuracy of the Lighting Estimation Technique

The one-time measurements of the lighting circuits in the two field test buildings did not prove to be an accurate method of estimating lighting loads. While this method was more successful in the retail store, the accuracy level was only ±26 percent. The accuracy could have been improved with more effort devoted to determining the lighting schedule during the transition periods. For the more complex office building, the estimated hourly lighting loads did not agree very well with the measured loads in either schedule or magnitude during building operating hours. The lighting load was difficult to estimate because no set usage pattern could be determined for the building as a whole. The accuracy level was estimated to be ±63 percent for the office building.

Even with a closer attention to the building's schedule, the projected range of the accuracy for the lighting estimation approach is ±20 percent for buildings with predictable regular hours and as high as ±50 percent for more complex buildings that do not operate on regular schedules.

3.1.7 Cost vs. Accuracy

Comparisons of the measurement methods in terms of cost effectiveness and accuracy requires that each method collect equivalent information. For this study's purpose, this involves the measurement of at least four end uses constituting at least 90 percent of the total building load. This measurement arrangement should accurately characterize a building's energy consumption. For Method 1 the acquisition of equivalent information under this scenario would require the use of up to three strip chart recorders. Up to four recorders would be needed in Method 2. No changes would be necessary for Method 3 as the microprocessor can calculate up to six end-use loads.

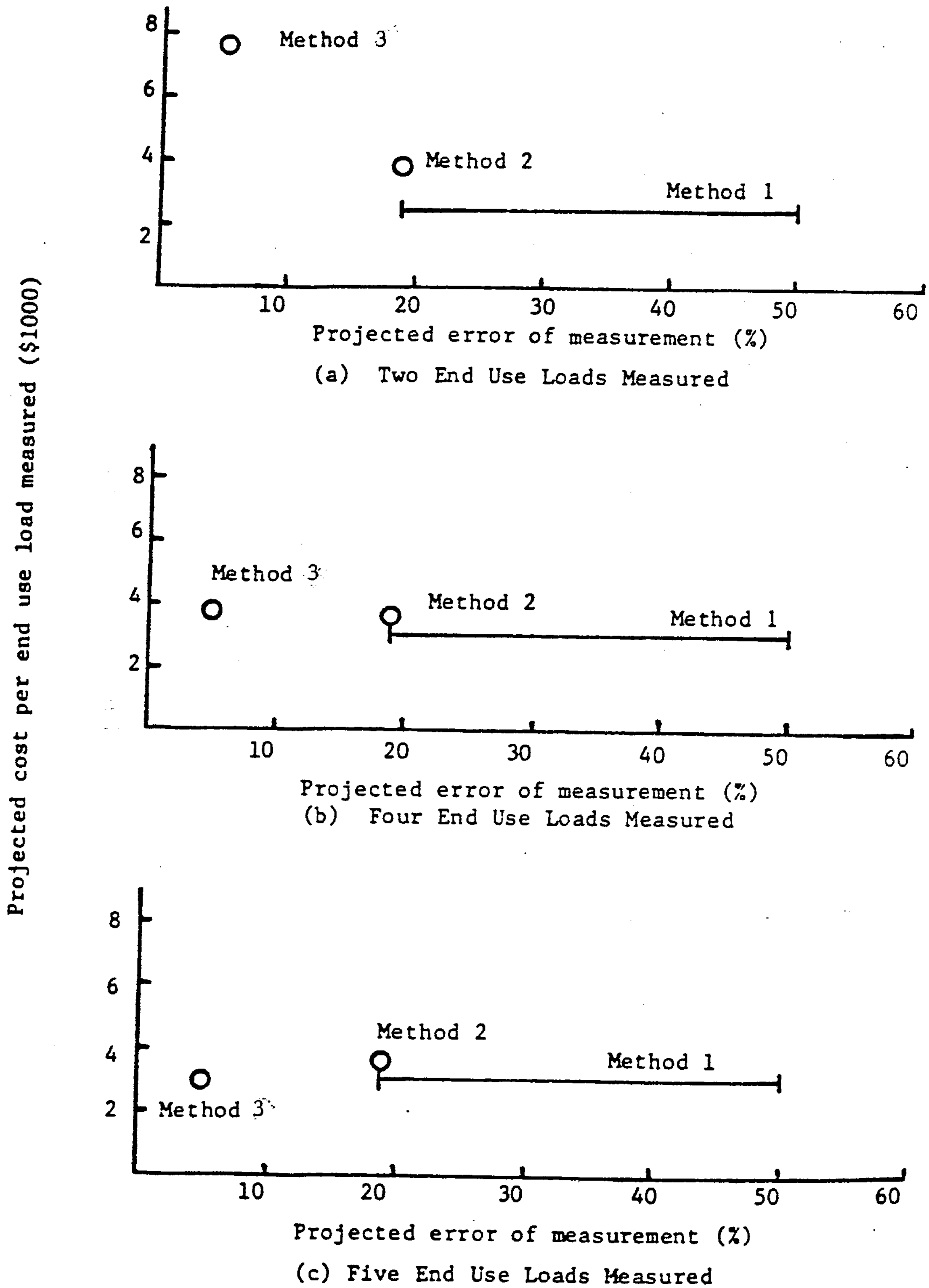
When two end-use loads are being monitored, Method 3, the microprocessor, works out to be the most expensive and Method 1 is the least expensive per end-use load monitored. Figure 3.1 shows that as the amount of data increases, the cost per end-use load decreases for Method 3, increases slightly for Method 1, and remains the same for Method 2. When five end uses are monitored, the microprocessor is the least expensive per end-use load monitored and the most accurate of the three measurement methods tested. Based on the results of the field test, it was determined that the microprocessor method of hourly end-use data collection was most suitable for commercial buildings.

3.1.8 Lessons Learned

The lessons learned from the field test of the different methods of data collection are many, but primarily refer to the root problem of the collection of accurate data. First, calibration of the equipment before and after the installation is necessary. A single one-time measurement was not a sufficient basis to calibrate the recording device, because often the equipment being monitored was not in operation during the first one-time measurement. Thus, calibration at a minimum of two different times would have been the correct way to calibrate the instruments, with field verification after installation ensuring collection of correct data. Second, it is not sufficient to measure only one phase of a three-phase circuit composing an end-use load because this can result in measurement errors. Assumptions that the three-phase circuits were balanced lead to measurement discrepancies because, in fact, they were unbalanced. Third, the use of split-core current transformers is desirable where power cutoff is not feasible for the placement of solid-core current transformers. This ensures that all loads are monitored, avoiding errors due to omission. Fourth, the microprocessor is the most accurate and cost-effective method of data collection of the three tested in the field test.

Figure 3.1

Projected Costs for the Alternative
Measurement Methods



Projected cost of each measurement method per number of end use loads monitored versus projected error of each method.

3.2 Additional Study Buildings

3.2.1 BPA Funding

The BPA recognized the regional importance of the field test and provided a $150,000 grant to City Light to expand the study to other building types. Six more buildings were added to the original two in the field test. They included an additional office building and nonfood retail store, two grocery stores, and two restaurants.

These buildings were primarily selected using the same procedures outlined for the selection of the field test buildings. In addition, nonrandom criteria such as presence of electric heat and size of establishment were considered. Five of the six buildings were selected from within the City Light random sample drawn for the commercial buildings rate study as part of Public Utilities Regulatory Policy Act (PURPA) requirements. In 1983 City Light instrumented over 200 randomly selected commercial customer meters to obtain hourly measurements of total load. The availability of these hourly PURPA measurements was useful for comparisons with the data obtained from the end-use monitoring equipment. Since there were no representative full-service restaurants within this sample, one building was selected from outside the sample.

3.2.2 Building Descriptions

A brief description of all eight study buildings is given below. Table 3.2 summarizes the building characteristics. The diagrams and a one-page summary sheet for each building are contained in Appendix A.

Table 3.2

Buildings Selected for the Commercial Hourly End-Use Study

Building Description	Floor Area Year Built	1985 Billed Electric Consumption and Kwh/sq.ft.	Heat Type
Retail #1 Drug Store	22,326 1973	446,920 20	Electric
Retail #2 Hardware	36,862 1962	613,898 17	Gas
Office #1 6 stories	89,550 1979	1,413,900 16	Electric - hydronic heat pump
Office #2 3 stories	14,920 1976	309,840 21	Electric
Grocery #1	24,800 1969	1,558,560 63	Electric - air-to-air heat pump
Grocery #2	16,843 1960	1,412,640 84	Gas
Restaurant #1 Fast Food	2,490 1976	266,460 107	Gas
Restaurant #2 24 hours	3,252 1970	342,000 105	Gas

3.2.2.1 Retail Building #1

This building is the retail store selected for the field test. The structural characteristics of the building are described in Section 3.1.3.1. The principal end-use load in this building is interior lighting, comprising 67.4 percent of the total electric energy consumed; outlets (10.3 percent), cooling (10.1 percent), heating (8.0 percent), and ventilation (4.2 percent) comprise the balance of the electrical load. The building uses electrical energy only and consumed an average of 30 kwh/sq.ft./yr in the past six years. This facility consumes the equivalent of 103,485 Btu/sq.ft./yr.

3.2.2.2 Retail Building #2

This retail store specializes in hardware, gardening supplies, and lumber and is open 81 hours a week. The average number of customers per hour is 164. Built in 1962, with modifications made in 1972, the building has a wood frame, a roof built up over a plywood deck, and walls constructed of concrete block. The building is a "U" shape incorporating three rectangular-shaped buildings. The total floor area is 36,682 sq.ft. Of this space, 91 percent is sales area and 9 percent is office and storage. Glass makes up 2.5 percent of the gross wall area. The heating system consists of 23 gas-fired unit heaters, which are manually controlled with thermostats set at 68° F. Cooling is controlled by roof exhaust fans operated during the summer months only. Interior lighting is fluorescent and exterior lighting is a mix of incandescent, fluorescent, and mercury vapor.

The principal electrical end-use load in this building is interior lighting, comprising 88.2 percent of the total electric energy consumed; outlets (9.9 percent) exterior lighting (1.4 percent), and hot water (.5 percent) comprise the balance of the electrical load. Natural gas is used for space heating. In the past six years, this facility has consumed annually an average of 19 kwh/sq.ft. and 12,000 therms (9.7 kwh/sq.ft. equivalent). This facility consumes the equivalent of 96,690 Btu/sq.ft./yr.

3.2.2.3 Office Building #1

This building is the office building selected for the field test. The structural characteristics of the building are described in Section 3.1.3.2. The principal end-use loads are lighting (34.4 percent of the total energy consumption), heat pump system heating and cooling (47.9 percent), and office equipment (17.7 percent). The building consumes the equivalent of 73,460 Btu/sq.ft./yr. The six-year average annual consumption for this all-electric facility is 22 kwh/sq.ft.

3.2.2.4 Office Building #2

This three-story office building is typically occupied 58 hours per week, from 8 a.m. to 6 p.m., Monday through Friday, and usually 10 a.m. to 2 p.m. on weekends. The average occupancy is 48 people. Built in 1976, the structure's roof is built up over a plywood deck and the walls are wood frame. The total floor area is 20,992 sq.ft., which includes a parking garage. Of the gross wall area, 12 percent is glass. The HVAC system consists of electric resistance duct heaters and direct expansion coolers. Heating and cooling temperatures are set at 70° F with a setback of 55° F when the building is unoccupied. Interior lighting is fluorescent. Parking garage lighting is mixed fluorescent and incandescent.

The principal end-use loads in this building are space heat (46.9 percent of total energy consumption), interior lighting (34.7 percent), outlets (18.1 percent), and elevators (0.3 percent). This all-electric facility has consumed an annual average of 21 kwh/sq.ft. in the past six years. This facility consumes the equivalent of 71,673 Btu/sq.ft./yr.

3.2.2.5 Grocery Store #1

This building is a large grocery store that is open for business 90 hours a week. The average number of customers per hour is 28. Built in 1969, the building was constructed on a concrete slab, has walls of concrete, and the roof is built up over a plywood deck. The total floor area is 24,800 sq.ft. Of this space, 71 percent is sales area, 19 percent storage, and 10 percent office. Seven percent of the gross wall area is glass. In the sales area the HVAC system consists of four electric heat pump units with cooling units. The office and lounge are served by unit heaters and baseboard units. Interior lighting is mostly fluorescent with some incandescent spots. Exterior lighting is all fluorescent.

The principal end-use loads in this building are refrigeration equipment such as walk-in coolers, walk-in freezers, display cooler cases, and display freezer cases (36.2 percent of total energy consumption); interior lighting (31.4 percent); space heat (16.7 percent); ventilation (11.3 percent); and processing equipment (4.4 percent). This all-electric facility has consumed annually an average of 60 kwh/sq.ft. in the past six years. This facility consumes the equivalent of 204,379 Btu/sq.ft./yr.

3.2.2.6 Grocery Store #2

This building is a large grocery store that is open for business 103 hours a week. The average number of customers per hour is 48. Built in 1960 and modified in 1974, the building was constructed on a concrete slab, has walls of concrete block, and a built-up roof over a plywood deck. The total floor area of the building is 16,843 sq.ft. Of this space, 53 percent is sales area, 18 percent refrigeration, 13 percent stockroom, and 12 percent office and lounge. Five percent of the gross wall area is glass. There is no cooling system in this building. A mix of gas-fired heaters, unit ventilators, and electric resistance heaters heat the building. Interior lighting is energy-efficient, surface-mounted fluorescent fixtures. Exterior lighting is mixed mercury vapor and fluorescent.

The principal electrical end-use loads in this building are refrigeration equipment such as walk-in coolers, walk-in freezers, display cooler cases, and display freezer cases (63.2 percent of the total energy consumption); miscellaneous equipment such as cash registers, meat and vegetable preparation equipment (5.5 percent); interior lighting (24.6 percent); exterior lighting (5.9 percent); and ventilation (0.8 percent). Although natural gas is used for space heating and domestic hot water, all other end uses are electrical. In the past six years, this facility has consumed an annual average of 88.1 kwh/sq.ft. and 7,129 therms (12.4 kwh/sq.ft. equivalent). This facility consumes the equivalent of approximately 343,000 Btu/sq.ft./yr.

3.2.2.7 Restaurant #1

This fast-food restaurant has both inside dining and drive-up window service. Hours of operation are from 6 a.m. to midnight in the dining area, and until 2 a.m. at the drive-up window. On weekends the restaurant is open 24 hours a day. The average number of customers per hour on weekdays is 15 and 25 on weekends. Built in 1976, the building was constructed on a concrete slab, with walls of concrete and a built-up roof over a plywood deck. The total floor area is 2,490 sq.ft. Of this space, 61 percent is work area and 39 percent is dining area. The HVAC system consists of a single-zone unit with cooling and natural gas heating. This system is manually controlled with thermostats set at 70° F for heating and 75° F for cooling. Interior lighting is a mix of fluorescent around the perimeter of the building and mercury vapor in the parking lot.

The principal electrical end-use loads in this building are food processing equipment such as french fryers, malt machines, and the grill (47.7 percent of the total energy consumption); lighting

(20.8 percent); refrigeration (16.8 percent); cooling (8.6 percent); and hot water (6.1 percent). Natural gas is used for cooking and space heating. All other end uses are electrical. In the past six years, this facility has consumed an average 124 kwh/sq.ft. and 7,400 therms (87.1 kwh/sq.ft. equivalent). This facility consumes the equivalent of 720,273 Btu/sq.ft./yr.

3.2.2.8 Restaurant #2

This building is a 24-hour "coffee shop" restaurant that is open seven days a week. The average number of customers per hour is 56. Built in 1970, the building was constructed on a concrete slab on grade, with wood-framed walls and a built-up roof over a plywood deck. The total floor area is 3,522 sq.ft. Of this space, 71 percent is dining area and 29 percent is work area. Of the total wall area, 28 percent is glass. The HVAC system consists of two packaged roof-top units. This system is manually controlled with thermostats set for heating at 64° F in the dining area and 68° F in the work area. Both areas have a cooling temperature of 73° F. Interior lighting in the dining area is incandescent with fluorescent in the work area. Exterior lighting is mixed incandescent, mercury vapor, and fluorescent.

The principal electrical end-use loads in this building are food processing equipment such as range and broilers (48.5 percent of total energy consumption); lighting (27.5 percent); refrigeration (12.1 percent); and ventilation (11.9 percent). Natural gas is used for cooking (range and broilers), space heating, and domestic hot water. All other end uses are electrical. The six-year annual average of consumption for this facility is 102 kwh/sq.ft. and 29,680 therms (267.4 kwh/sq.ft. equivalent). This facility consumes the equivalent of 1,256,980 Btu/sq.ft./yr.

3.2.3 Additional Installation of the Data Loggers

3.2.3.1 Dates of the Installation

As described earlier, the equipment in the two field test buildings was installed in January 1983 and data collection began in February 1983. The additional six commercial buildings were instrumented in the months that followed. For the two grocery stores and office #2, the equipment was installed and data collection started in April 1983. Retail building #2, and restaurant #1 had instrumentation and monitoring underway in June 1983. Equipment for the second restaurant was installed in July 1983 and data collection began in August 1983.

3.2.3.2 Costs of Post-Field Test Buildings

The itemized list of equipment costs per building is as follows (1983 dollars):

Processor board	$ 695
Multifunction board	484
Boot chip	72
Clock board	456
A/D board	1,050
Expansion board	521
Cassette tape drive	769
Card cage	209
Power supply	835
Enclosure	125
Tape cartridge	28
Voltage transformers	23
Current transformers	30
Wire	140
Miscellaneous hardware	140
TOTAL	$6,641

The itemized list of labor costs per building is as follows:

Assembly	$1,900
Calibration	400
Software	700
Installation	1,000
Checkout	468
TOTAL	$4,468

The total cost of instrumenting the six post-field test buildings was $66,654, or an average of $11,109 per building. This cost was approximately $4,000 less per building than that of the first two buildings, primarily due to the experience gained during the field test and the efficiencies gained from instrumenting six buildings at one time.

The total cost of equipment and labor for instrumenting all eight of the CHEUS buildings was $90,746. This cost has been substantially reduced in the BPA-sponsored ELCAP study described in Chapter 2 (Section 2.6.1). Labor and equipment cost per building in ELCAP is approximately $4,000-$6,000.

Chapter 4

HOURLY END-USE LOAD ANALYSIS

4.1 The Collection Procedures

4.1.1 The Steps

Hourly end-use load data cassette tapes are collected from the data loggers in the field on a monthly basis. The City Light meter is read to facilitate a comparison between the microprocessor and the meter. To result in a usable form in the end-use database, the data are reformatted from binary files to ASCII format to be compatible with the University of Washington Cyber Control Data Corporation (CDC) system. The formatting takes place in a VAX 11/780 mini-computer that uses computer programs to produce a 9-track magnetic tape in CDC format. City Light has its own disk pack at the ACC where data and quality checking programs reside. But before the monthly data are loaded on to the disk pack, the data are processed in a variety of ways. First, data are run through a program that creates a fileset for that data tape collection period. Second, each building's file of data within the fileset is checked for quality and quantity of data, producing an output report that describes the data. If the validity of the data is not questioned, then the third step is to load the monthly data onto the disk pack as random access files distinguishable by their unique building identification numbers. Once the data are appended to the random access file, specific periods of data can be extracted. These extracted files can be processed such that plots, graphs, and statistical descriptions are the result. Also, the data can be trans-ferred, or "down-loaded" to a floppy disk for use on a personal computer.

4.1.2 Routine Quality Control

Running the data through a quality checking program is important because the output report describes how accurate or inaccurate the data are. Thus, at any given time the quantity of data, the collection problems, microcomputer equipment failures, and how well the microcomputer data compares to the City Light meter data can be determined. The data-checking process aids City Light in determining the status of vast amounts of data.

The data are run through a data quality checking program that produces a report on the data for a given month. The report numbers can then be checked against the City Light meter and collection comparisons can be made. Thus, from checklist output one can determine if the data are within ± 5 percent of the meter readings (the goal) as well as the general quantity and quality of the data.

The customized checklist program sorts and reads the data file and performs the following quality checks:

a. Only records with valid dates are read.

b. Missing hours between data records are documented in an output file.

c. Data values that are invalid integers, less than or equal to zero, are replaced with -9s. These values are disregarded in future calculations.

d. Statistics for each channel are compiled and outputted to a report for use in comparison as well as outputted to a data quality data base.

e. A corrected version of the data file is stored in a fileset on the City Light hard disk at the ACC.

f. The output report of data quality is stored in a fileset at the ACC as well as in a database at City Light

Thus, the quality control process involves three elements. First, the data are checked using the procedures described above. Second, the output report of data collection is compared to the City Light demand meter data, such that a meter and micro comparison is made. Third, the information from the output report, such as data capture rates, missing hours, and relevant remarks, is stored in a database at City Light

4.2 Data Collected

As of year-end 1985, between 18 and 35 months of end-use load data have been collected for each of the CHEUS buildings. The numbers of months with valid data vary among the buildings for two reasons: the date data collection started and the extent of equipment problems encountered.

4.2.1 Quantity of Data Collected

Table 4.1 presents the quantity of data collected as of the end of December 1985. The general performance of the microcomputer data loggers has been very good, but there have been other equipment problems such as bad mechanical power switches, loose ground wires, or bad tape drives that have resulted in data losses. When all of the equipment is working, the majority of the time the data capture rates are equal to or closely approach 100 percent; but when equipment is not working correctly, then up to one month of data can be lost because the data tapes are only picked up once a month. As a result equipment problems can go unnoticed until tape pickup. Thus, an "all-or-nothing" principle of collection is at work--either an entire month is collected or an entire month is missed. Beginning in October 1985, tapes are being picked up twice a month to minimize loss of data.

Two of the buildings, office #1 and grocery #2, have fewer months of data due to equipment failure. Excluding these major periods of equipment failure, the average data capture rate across all of the buildings was 85 percent. Figure 4.1 displays the monthly capture rate information.

Table 4.1

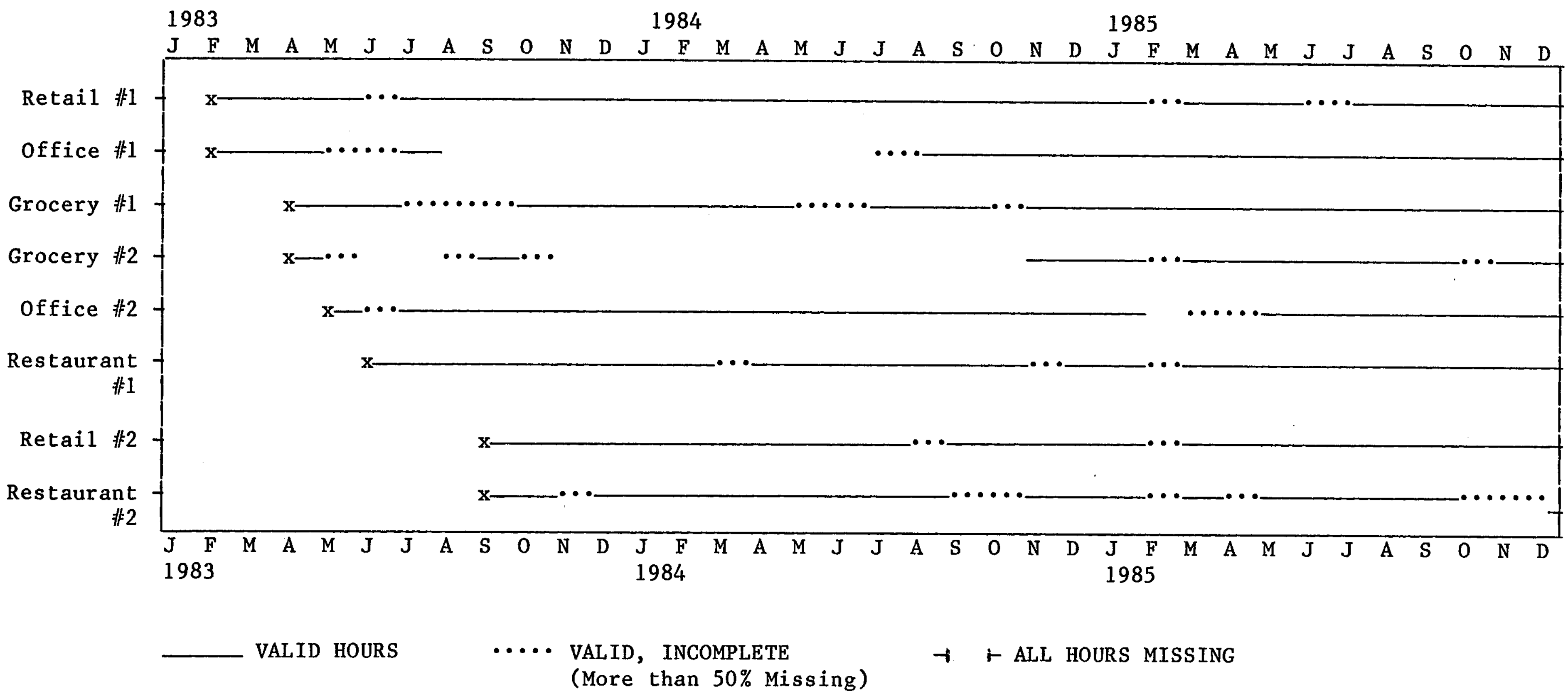
Quantity of Data Collected

Building	Data Start Date	Months Data of Collected	Average Capture Rate	Hours of Valid Observations 1983	1984	1985	Comment
Retail #1	2/01/83	35	94%	7,108	8,767	7,592	
Retail #2	6/17/83	28	88%	2,683	7,492	8,038	4 months missing 6-8/83, 4/84
Office #1	2/01/83	24*	85%	3,156	3,189	8,229	11 months missing 8/83-6/84
Office #2	4/27/83	31	89%	5,205	8,749	6,405	
Grocery #1	4/08/83	34	80%	4,606	5,607	8,415	Loose wires caused poor capture 3-5/84
Grocery #2	4/08/83	20*	77%	1,738	1,349	7,117	14 months missing 6, 7, 11, 12/83 1-8/84, 10/84, 1/85
Restaurant #1	6/08/83	30	91%	4,453	7,594	8,277	
Restaurant #2	8/26/83	27	91%	2,312	7,343	6,143	3 months missing 7/83, 9/84, 1/85

*Excludes months of missing data.

Figure 4.1

Months of Valid Data
Commercial Hourly End-Use Study
1983-1985



4.2.2 Edits Necessary to Ensure Quality of Data

In addition to the routine quality control procedures done while data are still at the VAX level of processing (described earlier), each month of data has additional edits done when the data reach the CDC system. Various editing programs have been developed which correct for specific problems in each building.

Table 4.2 and the following edit descriptions show the necessary monthly data edits for each CHEUS building.

Table 4.2

Data Quality Edits

Edit	Retail #1	Retail #2	Office #1	Office #2	Grocery #1	Grocery #2	Restaurant #1	Restaurant #2
Missing values	x	x	x	x	x	x	x	x
Power factor	x	x	x	x	x	x	x	x
Calibration/recalculation	x	x	x	x	x	x	x	x
Daylight savings	x	x	x	x	x	x	x	
Standard time								x
Remove double count				x		x		
Set to zero					x			

4.2.2.1 Missing Values/Bad Readings

When missing values (gaps between records) or bad values (due to equipment malfunction) are detected, they are replaced with a -9. This edit causes them to be disregarded in future calculations because they are defined as a missing value.

4.2.2.2 Power Factor

During the earlier routine quality checks, it was determined that power factors had not been included in the end-use channel computations. One-time measurements of power factor were to have been combined with voltage and current measurements to compute average energy demand per hour. The power factor edit applies the appropriate power factors to each building's data.

4.2.2.3 Calibration and Recalculation

If the data collection equipment is not calibrated after installation, then the end-use load data must be corrected with a calibration coefficient. The data value is recalculated using the appropriate coefficient and the building total and end-use channels are recomputed.

4.2.2.4 Time Adjustment

The microprocessor time clocks are not adjusted manually each year for the one-hour setback for Daylight Saving Time. Seven of the eight buildings are always on Pacific Standard Time. The eighth building is always on Daylight Saving Time. Computer programs were developed to correct the time. One program "springs ahead" the Pacific Standard hours to Daylight Saving Time in the summer for the seven buildings. The other "rolls back" the Daylight Saving Time to Pacific Standard Time during the winter months for a single building. Another program adjusts the time for leap years.

4.2.2.5 Remove Double Count

An error in the measurement plan equation for both office buildings resulted in the double counting of energy consumption for one of the channels composing the outlet end use. This edit removes the double-counted value as well as re-computes the new building total.

4.2.2.6 Set to Zero

A few channels consistently record small negative numbers where zeros should actually appear. This edit sets these values to zero.

4.2.3 Data Quality Results

The total building load monitored by the end-use data loggers matched well with City Light's metered level of consumption. Except for two buildings needing additional data edits, the annual monitored loads and City Light's measurements were within 7 percent. The monthly deviations fluctuated between ±12 percent. These results are within the accuracy range of the end-use data logger equipment as discussed in Chapter 3.

This check on the quality of the data editing was obtained by comparing the end-use monitored total load against City Light's hourly measurements using a four-channel magnetic tape recorder. In the case where a City Light recorder was not installed in a study building (restaurant #2), and where the recorder measured only one of the building's two meters (retail #2), City Light's monthly readings for billing purposes were used for the comparison. Table 4.3 displays the annual consumption comparisons. Two exceptions are noted below where additional data editing will be necessary.

Table 4.3

Comparison of Data Logger and City Light Measurements
(Average Hourly Kilowatts)

	N*	Monitored Building Total	City Light Measurement	Percent Difference
Retail #1				
1984	8743	81.4	79.7	+ 2.1
1985	7518	60.6	54.1	+12.0**
Retail #2				
1984	7476	87.8	86.5	+ 1.5
1985	8024	71.4	70.2	+ 1.7
Office #1				
1984	3179	178.3	182.2	- 2.1
1985	7552	146.3	149.3	- 2.0
Office #2				
1984	8726	36.9	34.4	+ 7.3
1985	6390	28.4	32.2	-11.8***
Grocery #1				
1984	5593	178.9	80.0	- 0.6
1985	8405	172.3	172.6	+ 0.2
Grocery #2				
1984	1347	160.5	161.5	- 0.6
1985	7103	162.6	161.2	+ 0.9
Restaurant #1				
1984	7581	34.7	33.6	+ 3.3
1985	7749	32.6	32.3	+ 0.9
Restaurant #2				
1984	7369	36.9	38.9	- 5.3
1985	6143	38.7	38.8	- 0.4

*Number of hours where both City Light measurements and end-use monitored data existed.
**Lighting channels need calibration January-July 1985.
***One of four heating channels missing data September-December 1985.

4.3 Preliminary Results (not weather adjusted)

4.3.1 Introduction

The preliminary results from hourly end-use analyses indicated that the largest share of electricity use was lighting in the retail stores, space conditioning (heating, ventilation and cooling) in the office buildings, refrigeration in the grocery stores, and food processing equipment in the restaurants.

Table 4.4 presents each electric end-use load as a percentage of total electrical consumption for each of the CHEUS buildings.

In order to put the electrical end-use share information in perspective, it is helpful to have some knowledge of the climate of the area. Seattle typically has mild temperatures. The area has neither extreme cold nor hot temperatures in winter or summer. Thus, with the exception of office buildings, electrical heating and cooling end-use loads do not dominate the annual electricity consumption.

Table 4.4

Electrical End-Use Share Distribution
1985 Data

	Retail		Office		Grocery		Restaurant	
	#1	#2	#1	#2	#1	#2	#1	#2
Lights Total	67.4	89.6	34.4	34.7	31.4	30.5	20.8	27.5
Interior		88.2				24.6		
Exterior		1.4				5.9		
HVAC Total	22.3	*	47.9	46.9	28.1	0.8	8.6	11.9
Heat	8.0		16.0					
Cool	10.0		1.3				8.6	
Vents	4.3	*	1.9		11.3	0.8		
Heat pump			28.7		16.8			
Refrigeration					36.2	63.2	16.8	12.1
Process Total					4.3	5.5	47.7	48.5
Large								32.6
Small								15.9
Hot water		0.5					6.1	
Elevator				0.3				
Misc. other	10.3	9.9	17.7	18.1				
Percentage TOTAL	100	100	100	100	100	100	100	100
(kwh/sq.ft.)	23.8	17.1	15.1	17.1	61.0	83.9	115.5	106.0

*Negligible amount.

4.3.2 Seattle Weather[1]

Seattle's proximity to the Pacific Ocean and the topography of the area are two factors influencing the area's weather. The Pacific

[1] James E. Overland and Bernard A. Walter, Jr., "Marine Weather of the Inland Waters of Western Washington," NOAA Technical Memorandum ERLPMEL-44 (January 1983) pp. 1-6.

Ocean moderately influences the weather of the area through wind patterns. Westerly and northwesterly winds and high-pressure zones over the ocean cause a dry season that begins in June and peaks in midsummer. The high-pressure zones move south during the winter, which allows storms to enter the area and results in a wet season that begins in October, peaks in the winter, and decreases in the spring.

The topography of the region greatly influences Seattle's weather. Two mountain ranges, the Olympics to the west and the Cascades to the east, protect the region in many ways. The Olympics act as a barrier to the winter storms on the Pacific Ocean and cause much of the storm rain to fall on the west side of the mountains. The Cascades protect the area from the cold air moving across Canada.

Heating degree days (HDD) are useful measures of a particular area's weather over a period of time. They are especially valuable when making comparisons across the different aggregations of month, day, and year and in comparing the general climate of different geographical locations. HDD are computed by averaging the high and low temperatures of the day and subtracting 65. The result of this calculation is the heating degrees for a particular day. A month of HDD is simply a summation of each day's heating degrees.

October through March are Seattle's winter months and April through September are Seattle's summer months. Table 4.5 presents an overview of Seattle weather patterns.

Table 4.5

Typical Seattle Winter and Summer Weather

	Winter (October-March)	Summer (April-September)
Typical Temperatures		
Daytime	40s	70s
Nighttime	30s	50s
Degree Days		
Heating	5100	
Cooling		200
Sunshine	30%	58%
Rainfall	29"	9"

Table 4.6 presents 1951-1980 normal degree days and 1983-1985 HDD and their percentage of the norm. In this way it is possible to see recent trends in Seattle's weather and how annual and monthly HDD compare to the 30-year norm. Typically, one would say that

temperatures have been quite mild and close to the norm, with the exception of a few extremely cold winter months such as December 1983 with 890 HDD, December 1984 with 868 HDD, and November and December 1985 with 870 and 888 HDD, respectively.

Table 4.6

Sea-Tac Annual Heating Degree Days (HDD)

Month	1951-80 Normal DD	1983 HDD	% of Normal	1984 HDD	% of Normal	1985 HDD	% of Normal
Jan	803	613	74	672	81	857	103
Feb	622	502	79	577	88	719	113
Mar	645	479	74	507	78	666	103
Apr	489	422	86	482	99	469	96
May	313	244	78	372	119	310	99
Jun	169	149	89	183	110	160	95
Jul	76	72	90	54	68	8	11
Aug	97	19	23	42	51	48	49
Sep	169	196	115	159	94	199	118
Oct	388	406	102	467	118	413	106
Nov	606	511	83	604	99	870	144
Dec	744	890	117	868	114	888	119
Totals	5,121	4,503	88	4,985	97	5,607	109

4.3.3 Analysis of Individual Buildings

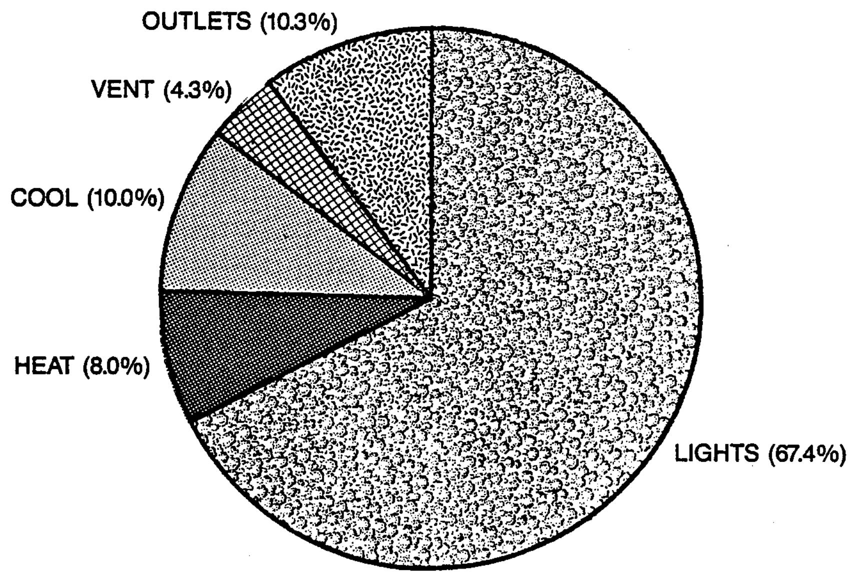
The collection of hourly end-use load data provides unique opportunities to examine load patterns in detail. These patterns aid in explaining consumption patterns in particular buildings and building types. In addition to annual end-use shares for individual buildings, monthly averages and average weekday end-use profiles for summer (April to September) and winter (October to March) are useful for analyzing and reporting hourly end-use load data.

Graphs that present monthly averages of end-use consumption are helpful for observing seasonal changes in a building's heating and cooling system. Average weekday graphs are helpful in analyzing the effects of building operating hours, equipment schedules, and daily temperature fluctuations. Seasonal weather sensitivity on daily loads can be seen from the comparison of the summer and winter average weekday profiles.

Figure 4.2

RETAIL #1 — ANNUAL ELEC CONSUMPTION

by End Use — 1985



20.0 kwh/sq.ft.

4.3.3.1 Retail Store #1

In retail store #1 total electric consumption is clearly dominated by the lighting end use, which comprises nearly 70 percent of annual share. At the monthly level of analysis, lighting remains at a relatively constant level with the HVAC loads fluctuating with the seasons. Since November 1984 there has been a significant drop in consumption caused by an owner-initiated lighting retrofit. The impact of this will be discussed in Chapter V. The weekly profiles reflect the store's shorter business hours on weekends. Profiles of average weekdays in the summer and winter seasons show that most end-use loads behave consistently across the seasons with the exception of the heating and cooling. In winter there is a typical morning heat spike that tapers off to maintenance levels by noon, along with a slight rise in cooling in the late afternoon. During the summer the heat spike is replaced by cooling that begins in the morning, peaks in the late afternoon, and decreases to maintenance levels when the store is closed.

Figure 4.3

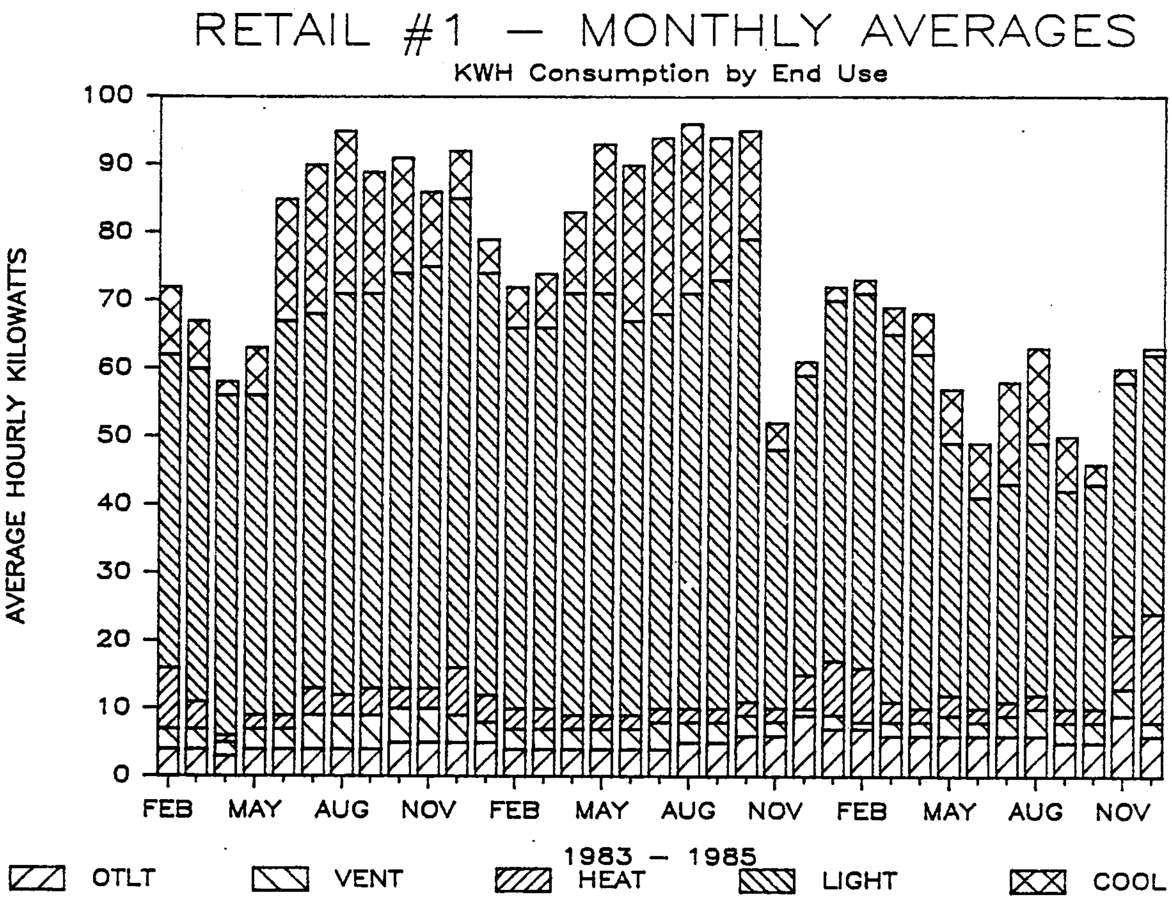
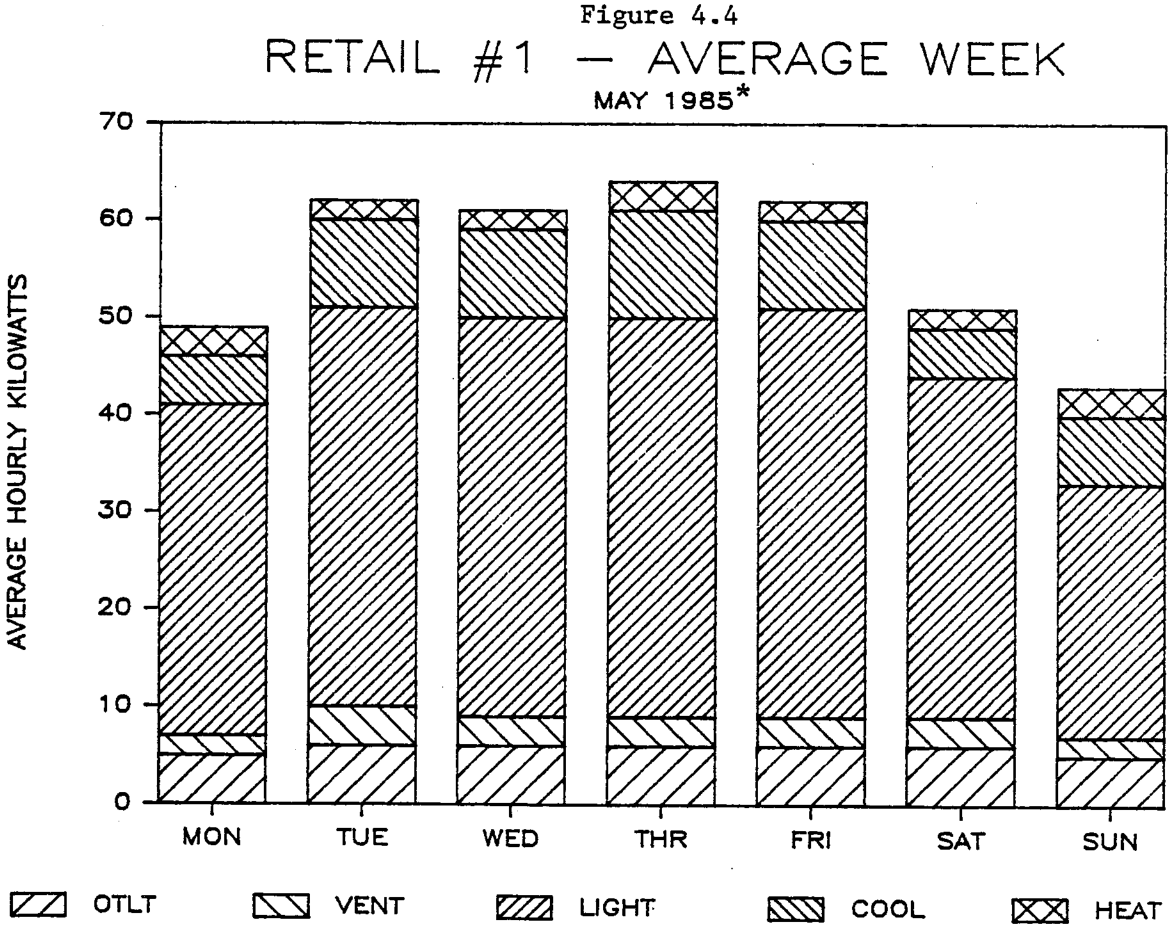
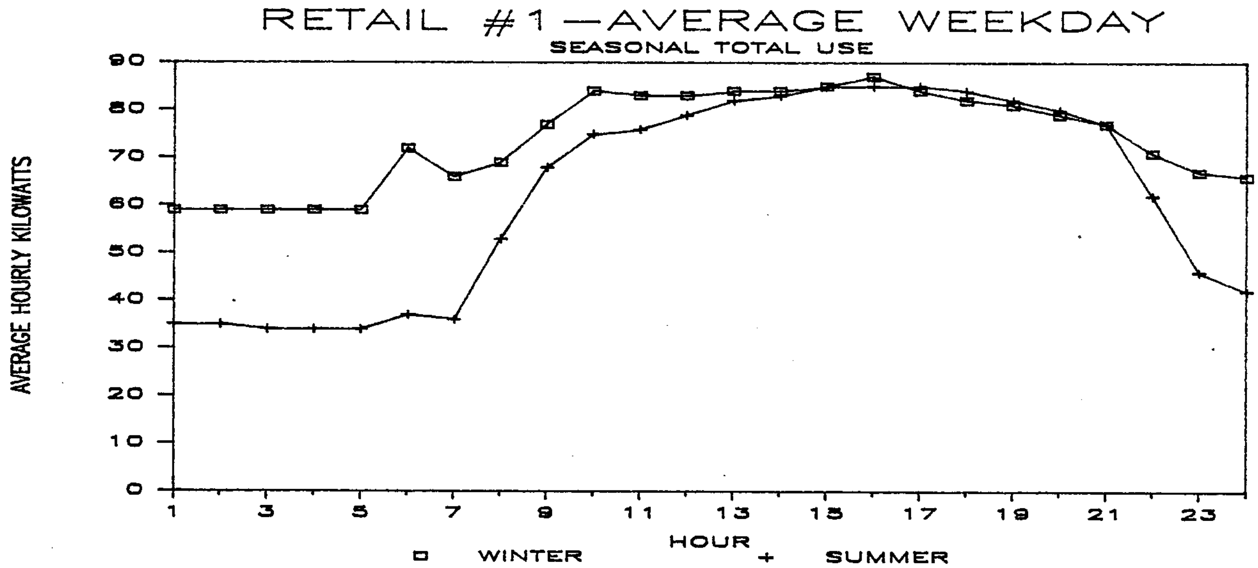


Figure 4.4



* Includes Memorial Day Holiday

Figure 4.5



October '84 - March '85 April '85 - September '85

Figure 4.6

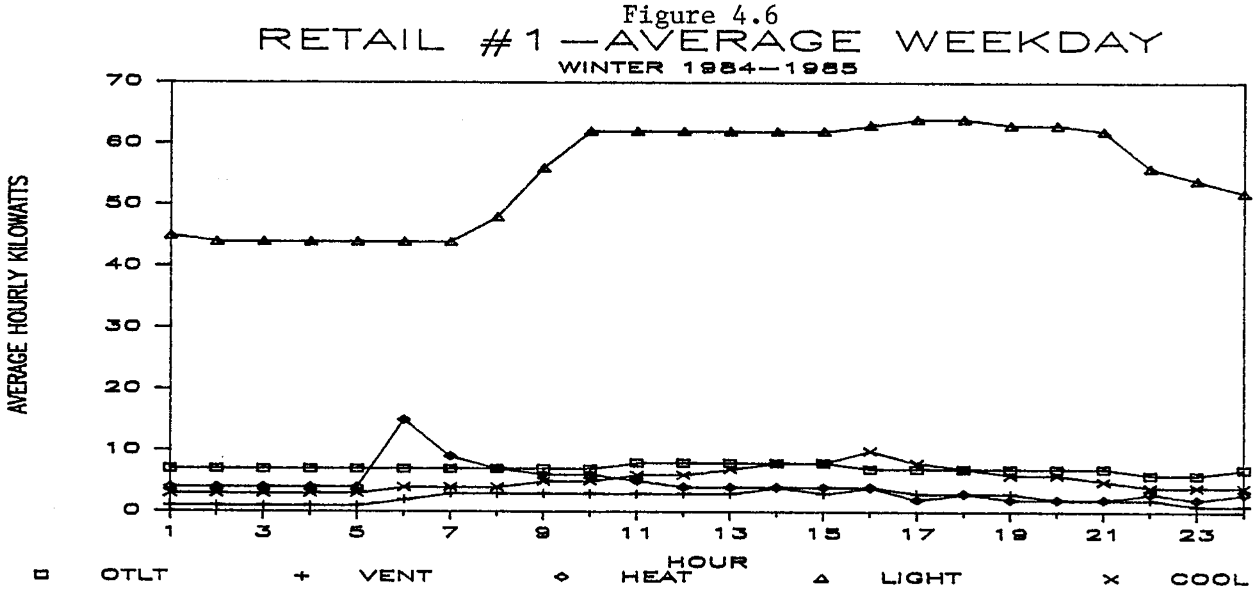


Figure 4.7

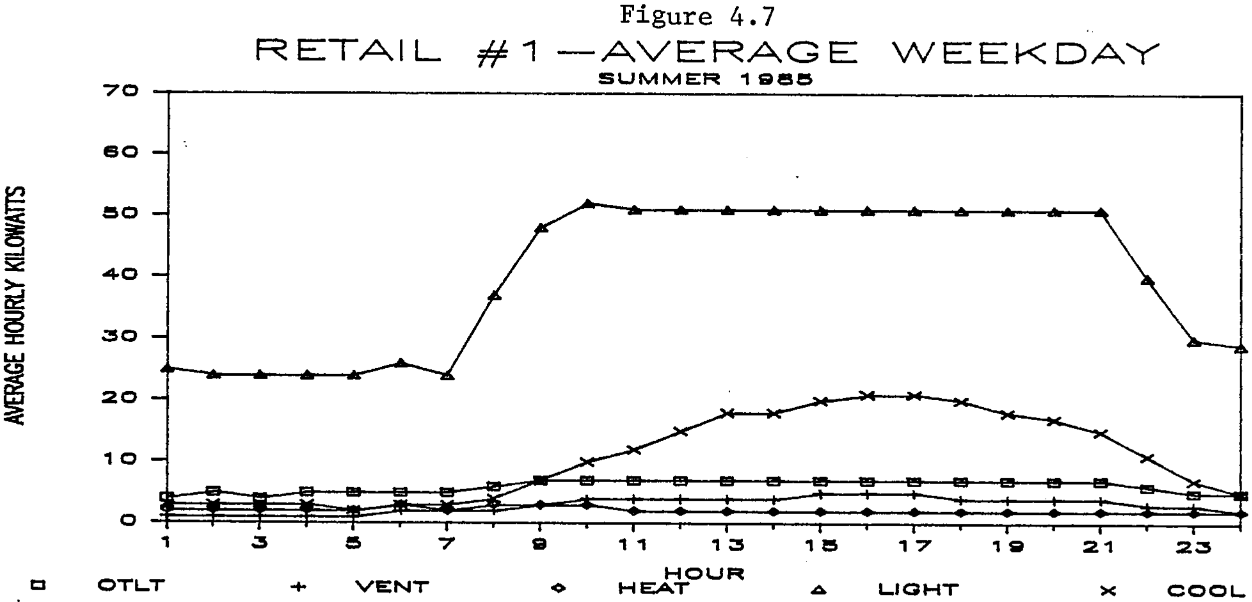
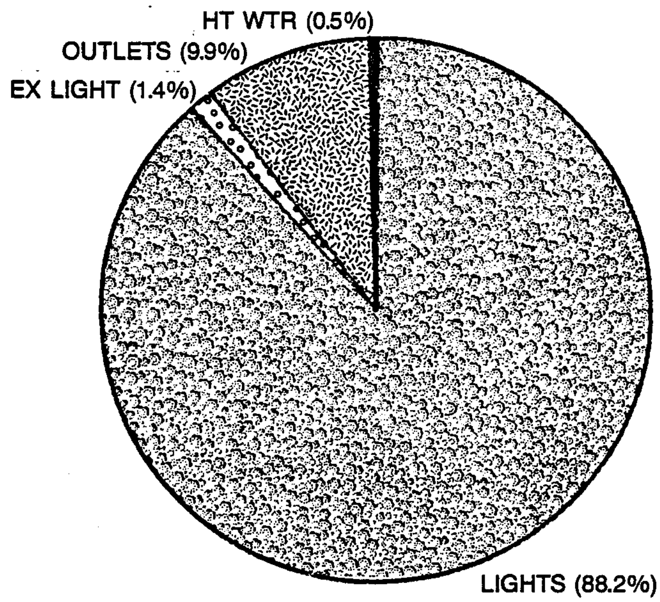


Figure 4.8

RETAIL #2 — ANNUAL ELEC CONSUMPTION

by End Use — 1985



16.7 kwh/sq.ft.

4.3.3.2 Retail Store #2

In the gas-heated retail store #2, lighting is the dominant electrical load, comprising approximately 90 percent of the total electric consumption. The end-use shares in this building remain quite uniform regardless of the time of year, with the exception of the winter of 1983 when consumption had a definite peak probably due to the weather. The weekly profile shows the variation in business hours for weekdays and weekends. While the store's business hours are the same for winter and summer months, the higher level of lighting in the off hours in the winter reflects increased late-night restocking activity in the building. The other end uses consume small but relatively constant levels of electricity. Seasonal weather change does not seem to significantly affect the electrical energy consumption in this building.

Figure 4.9

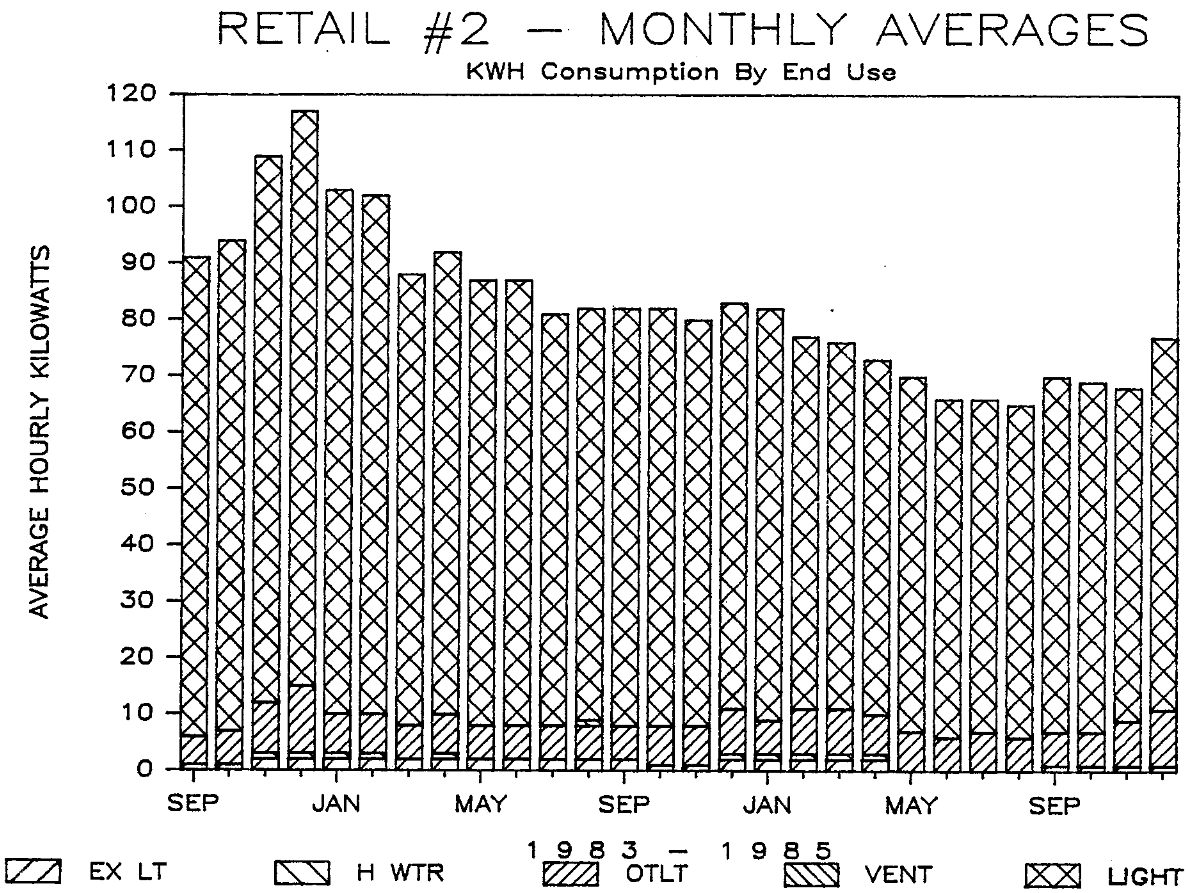
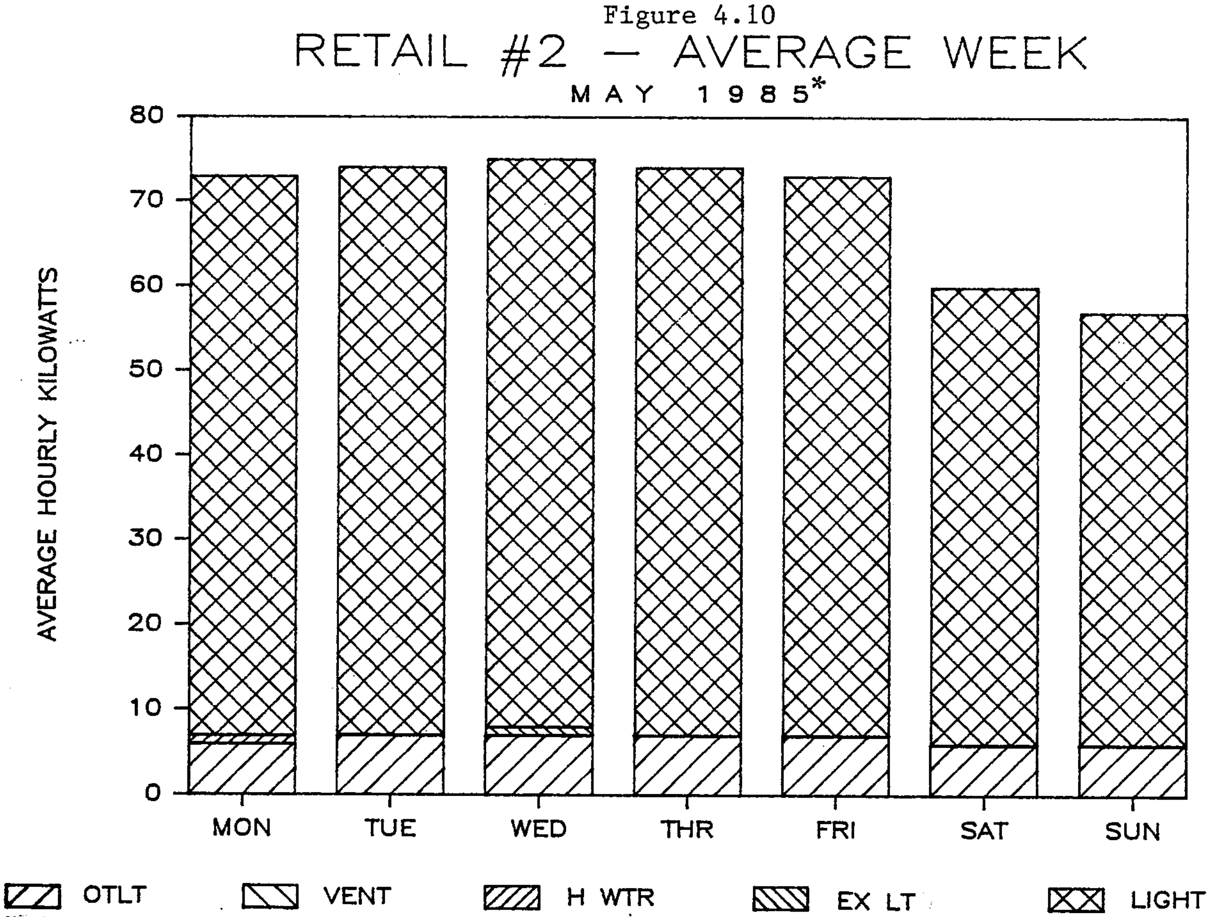
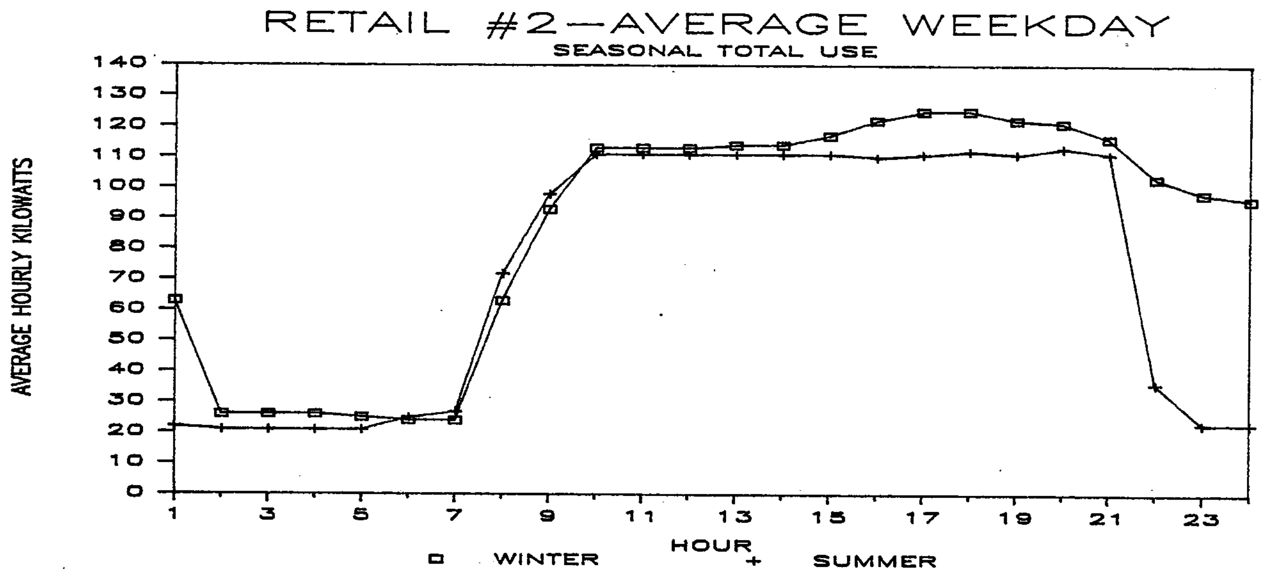


Figure 4.10



* Includes Memorial Day Holiday

Figure 4.11



October '84 - March '85 April '85 - September '85

Figure 4.12

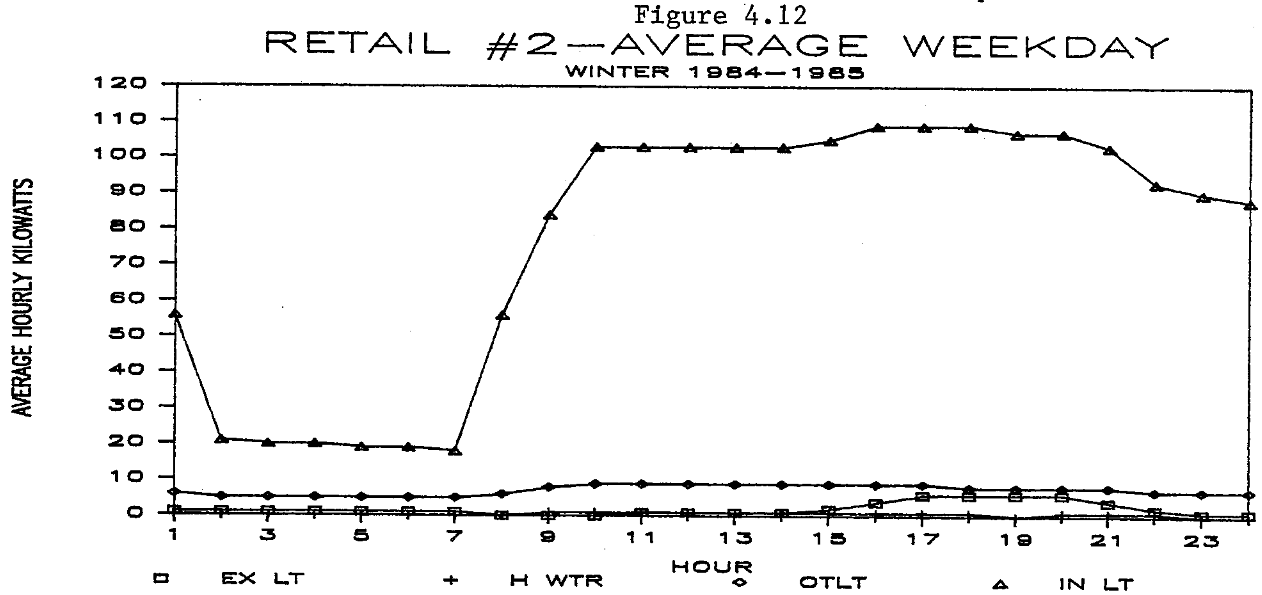


Figure 4.13

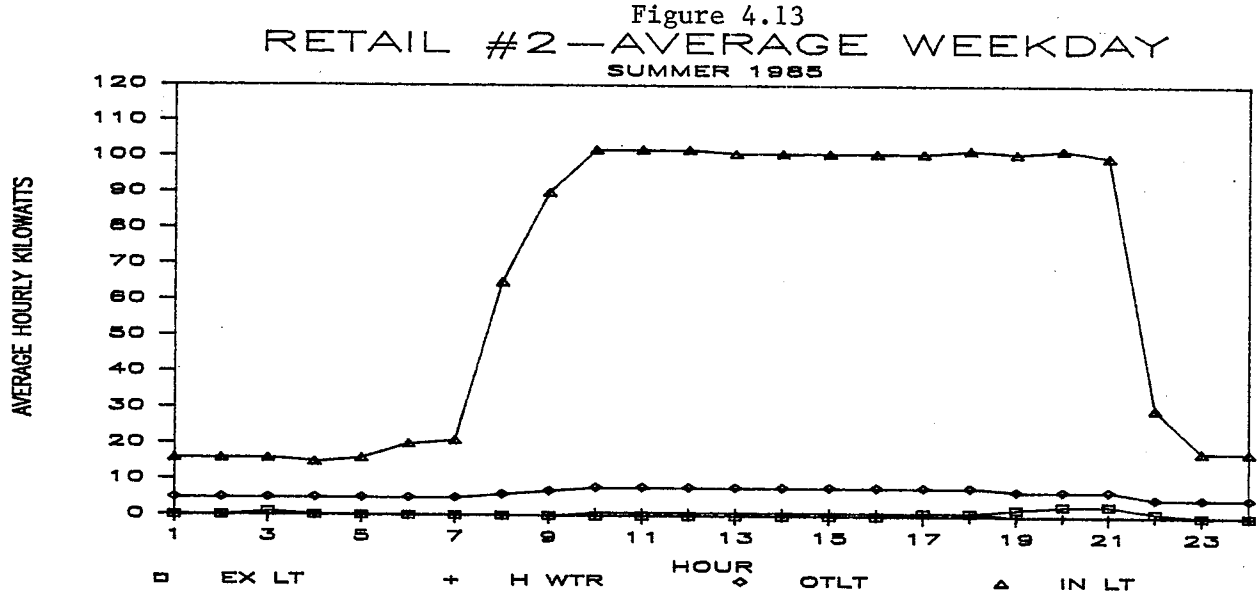
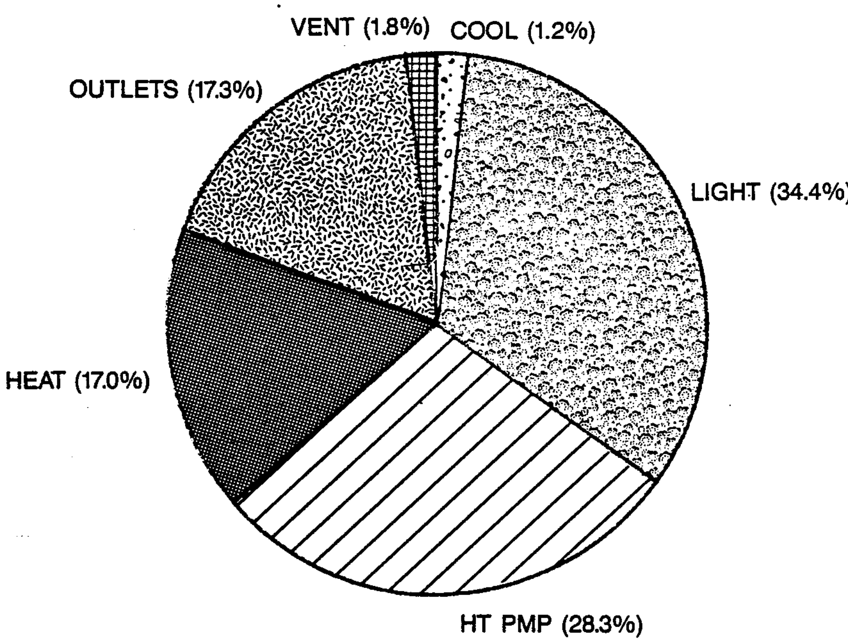


Figure 4.14

OFFICE #1 — ANNUAL ELEC CONSUMPTION
by End Use — 1985



15.8 kwh/sq.ft.

4.3.3.3 Office #1

In the all-electric office #1, consumption by end use shows considerable variation across the months. Also, this variation does not seem to be wholly weather related, because the lighting end-use share fluctuates significantly across the months. The heat pump and ventilation end uses behave uniformly, while heating fluctuates depending on the season. At the weekly level the building loads operate at minimal levels on the weekend and operate fully during the weekdays. The load profiles of average weekdays during the winter and summer show all loads closely following business hours. During the winter the heating is more active, and the lighting consumption is considerably higher than in the summer.

Figure 4.15

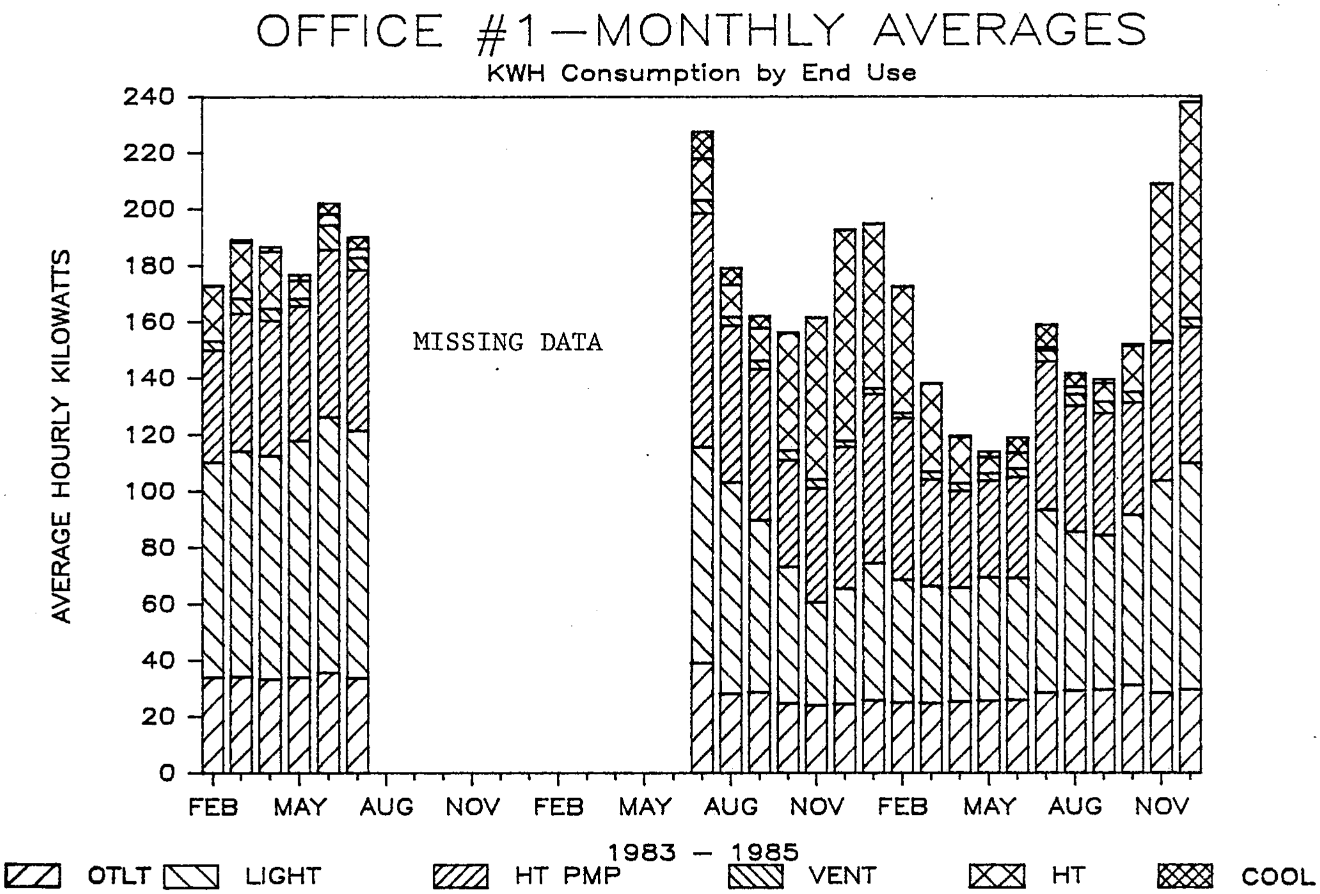
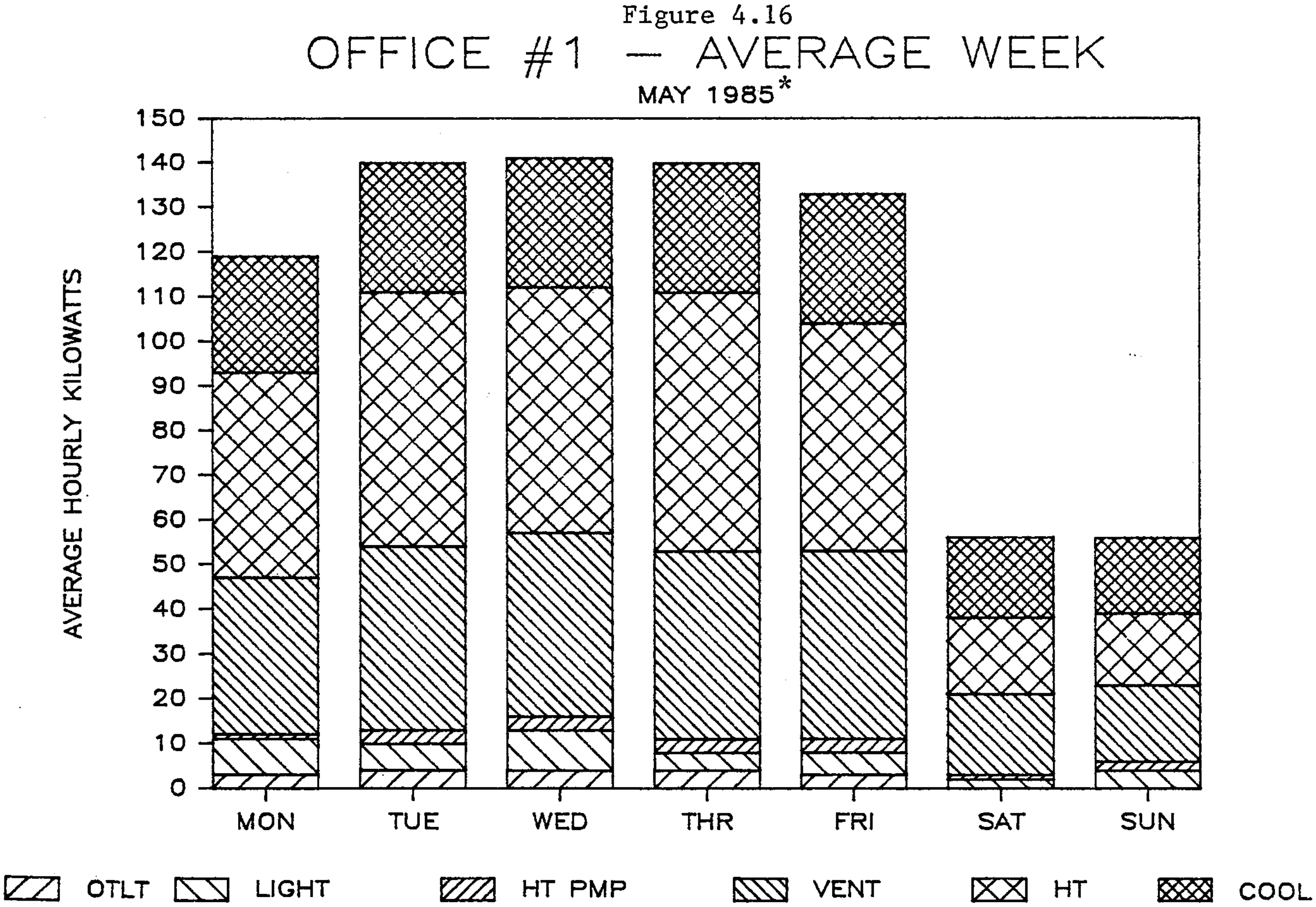
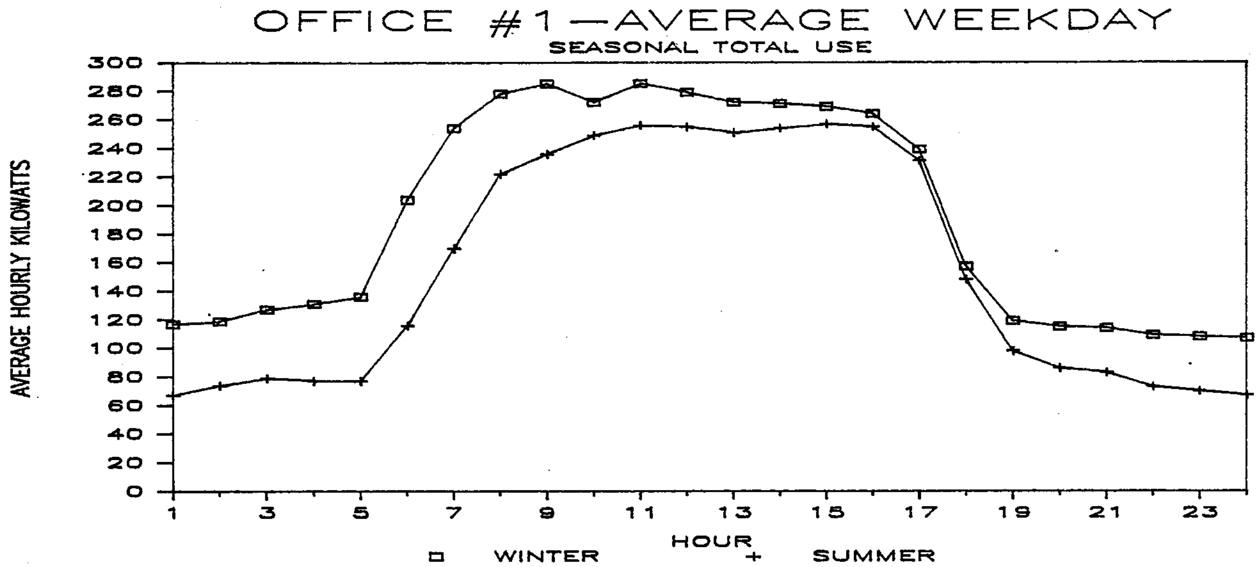


Figure 4.16



*Includes Memorial Day Holiday

Figure 4.17



October '84 - March '85

April '85 - September '85

Figure 4.18

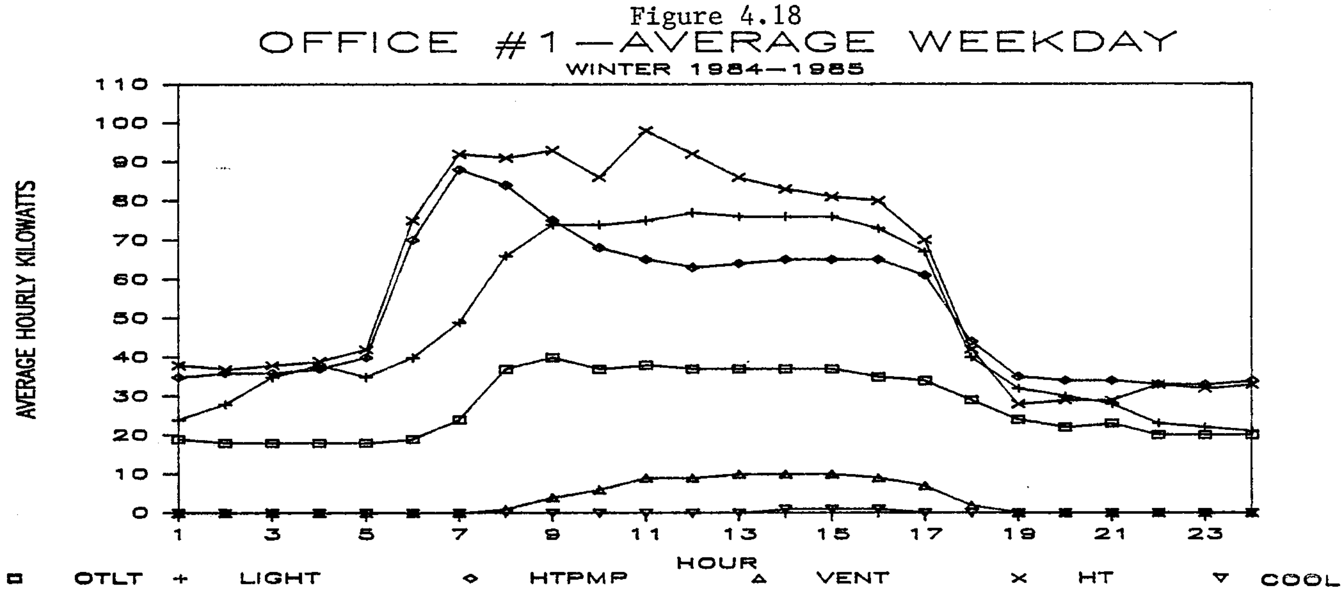


Figure 4.19

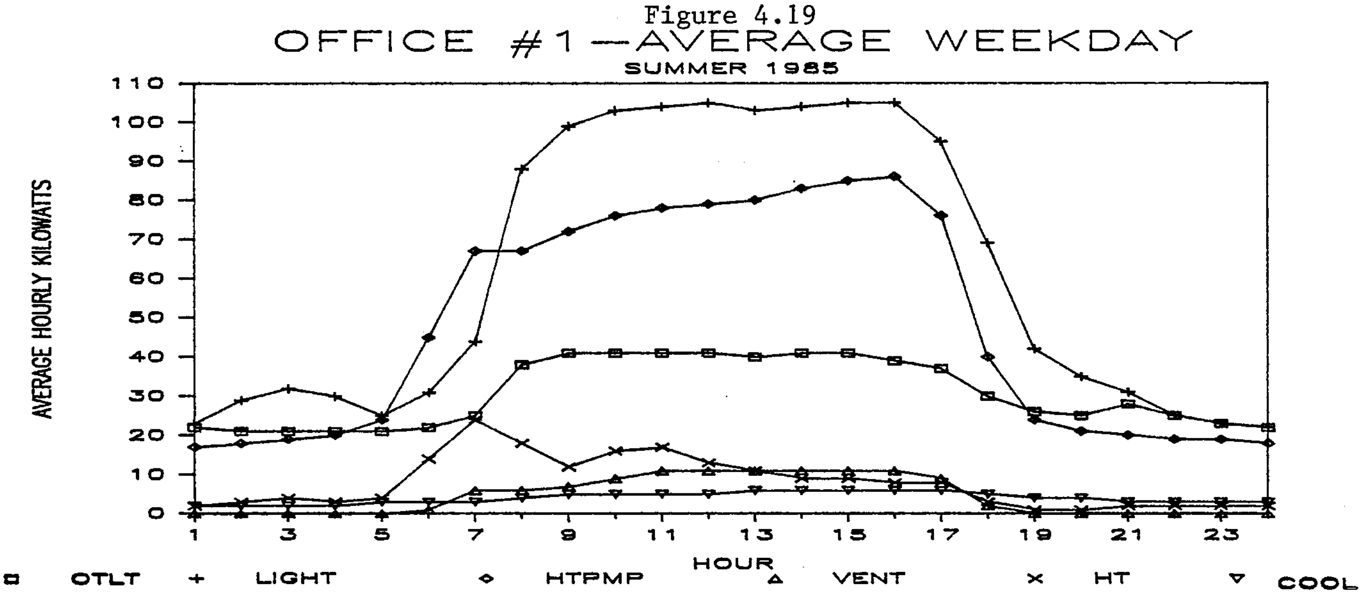
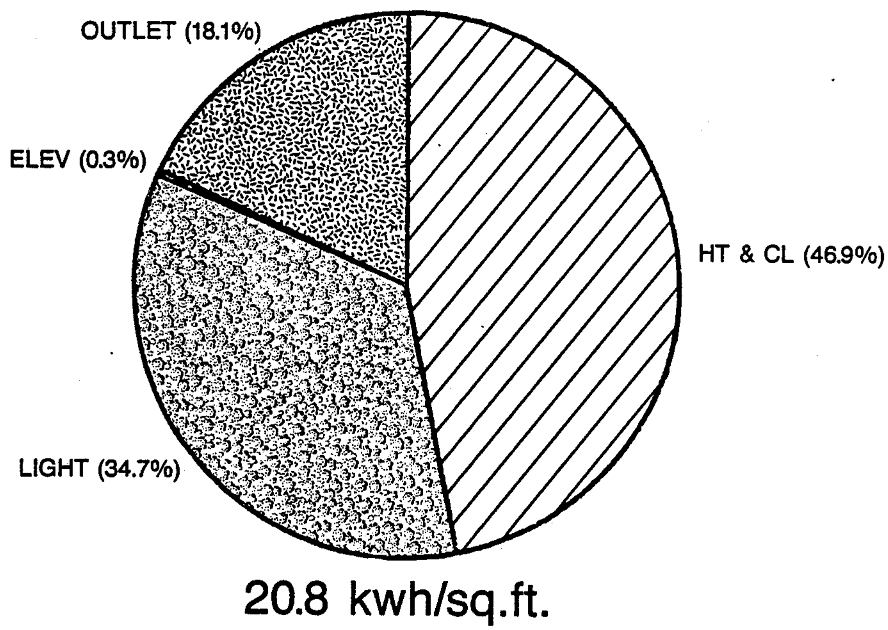


Figure 4.20

OFFICE #2 — ANNUAL ELEC CONSUMPTION

by End Use — 1985



4.3.3.4 Office #2

In office #2 end-use consumption is quite uniform across the months of the year, with peaks in consumption for the heating/cooling (HT&CL) load during the winter. The consistency with which total consumption rises and falls shows this building to be weather sensitive. The weekly profile shows work activity is the lowest on the weekends. During the winter the heating/cooling end use rises at 5 a.m. when the night temperature setback is no longer in effect, peaks at 8 a.m., and decreases throughout the rest of the day. Other loads closely follow the business hours of the building. In the summer the entire profile follows the business hours, with heating at the start of the work day and cooling throughout the afternoon.

Figure 4.21

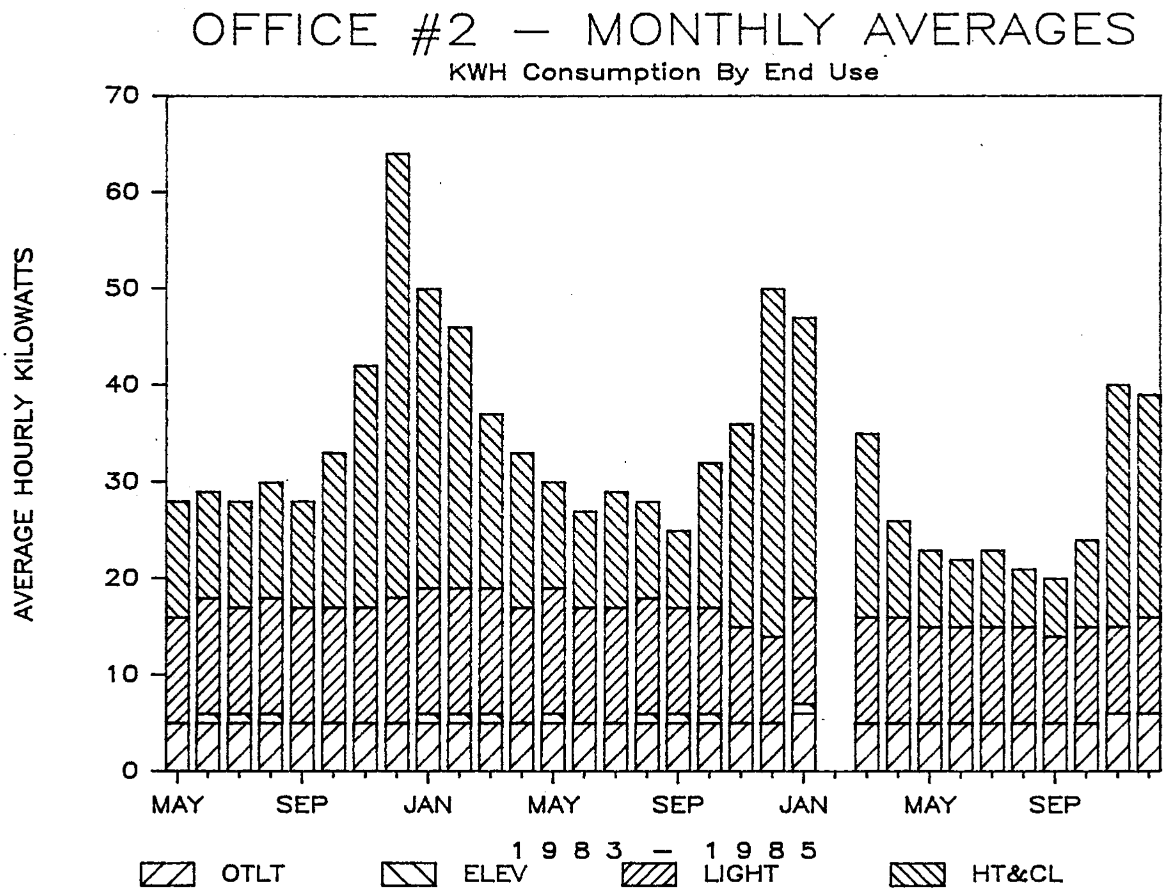
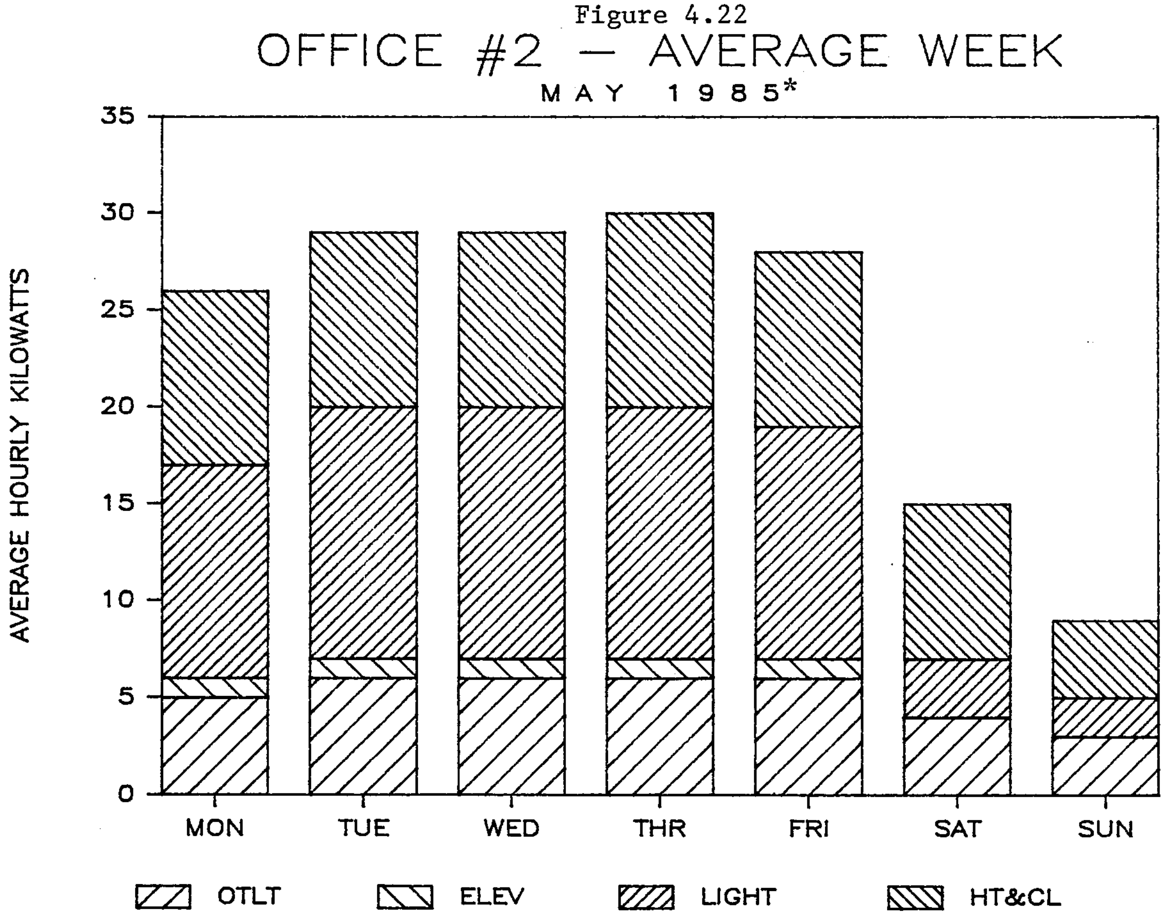
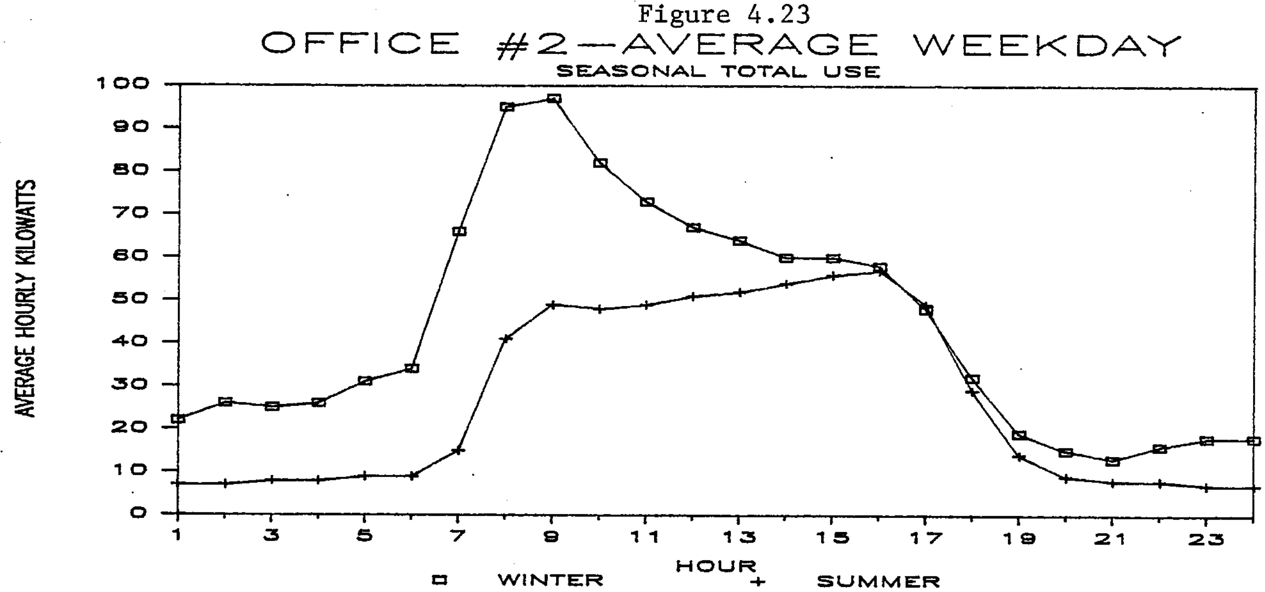


Figure 4.22



*Includes Memorial Day Holiday

Figure 4.23



October '84 - March '85 April '85 - September '85

Figure 4.24

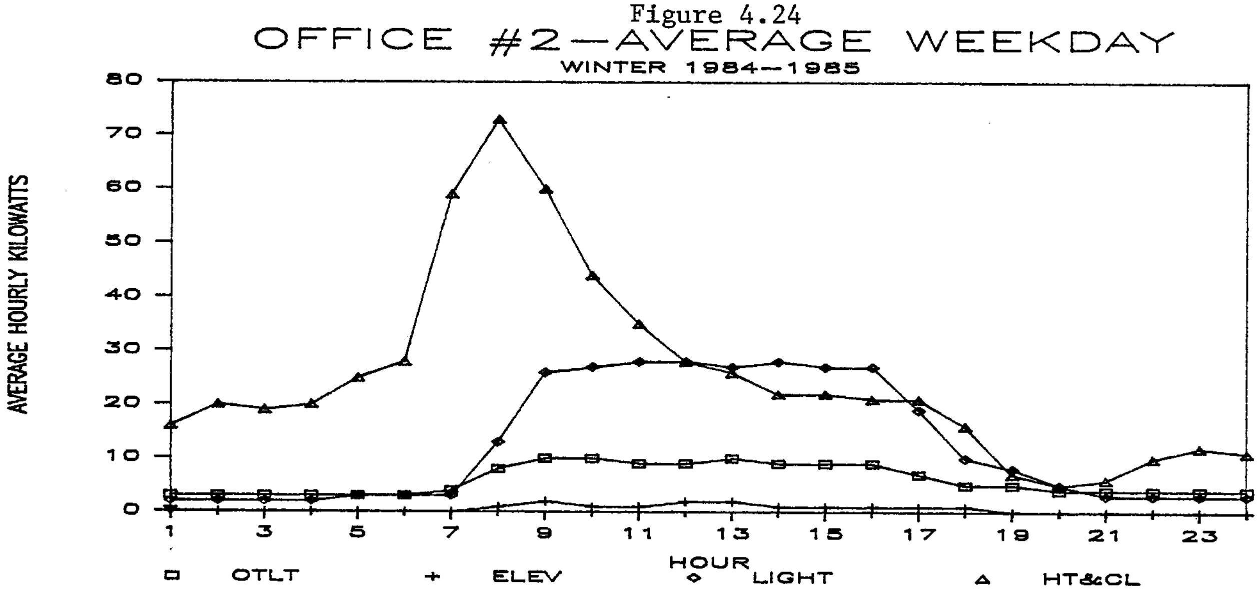


Figure 4.25

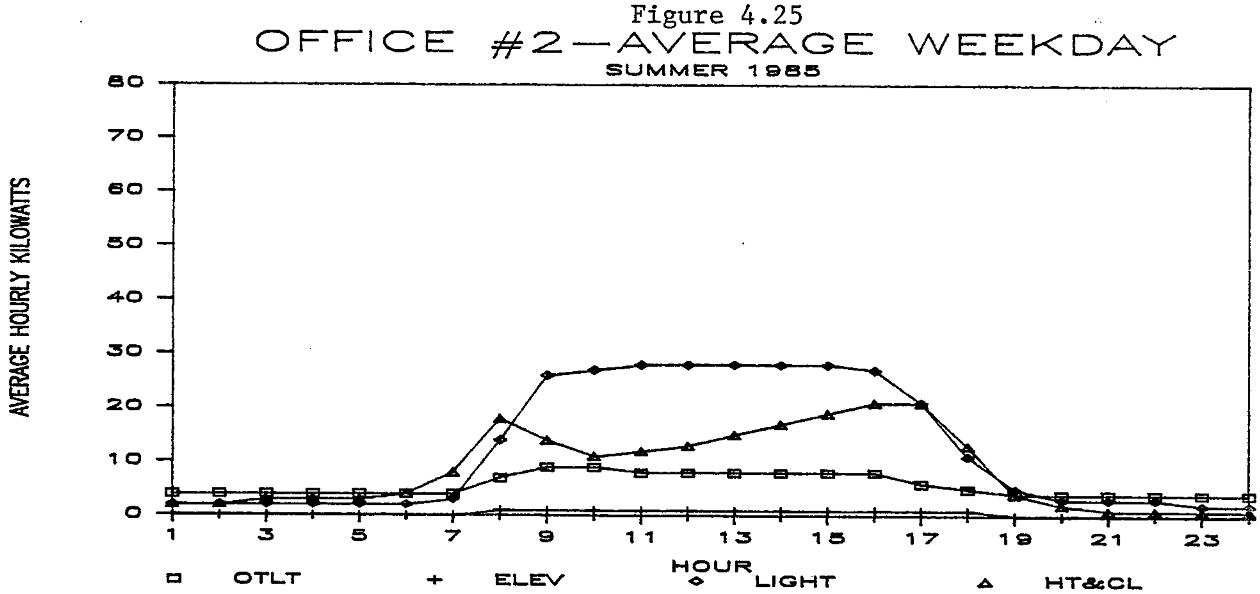
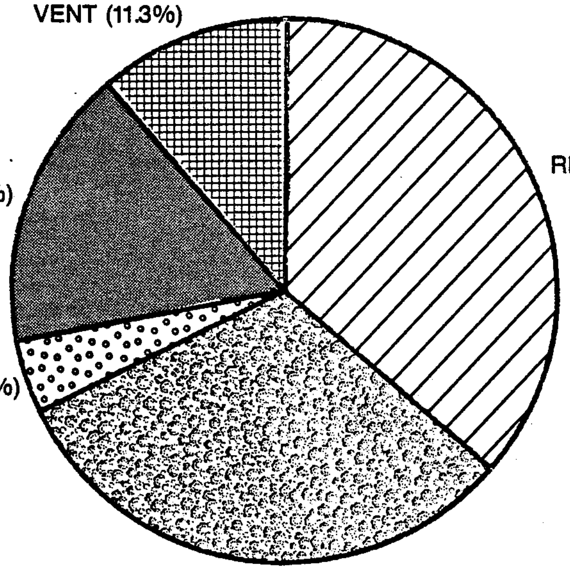


Figure 4.26

GROCERY #1 — ANNUAL ELEC CONSUMPTION

by End Use — 1985



62.9 kwh/sq.ft.

4.3.3.5 Grocery #1

In grocery store #1 all of the end uses are always in operation due to the nature of the business. At the monthly level of analysis, the loads are constant except for the heat pump (HT PMP), which is weather sensitive and peaks during the winter. At the weekly level there is little variation of the end-use share except for lighting, which is probably related to night restocking and cleaning activities. Average weekday profiles for the winter and summer show fluctuations across the hours of the day for the lighting and refrigeration end uses. Lighting levels change depending on business hours. Refrigeration (REFRG) always operates at a certain level but peaks a few times a day during the defrost cycles. During the summer the heat pump operates at approximately 20 percent of its winter level.

Figure 4.27

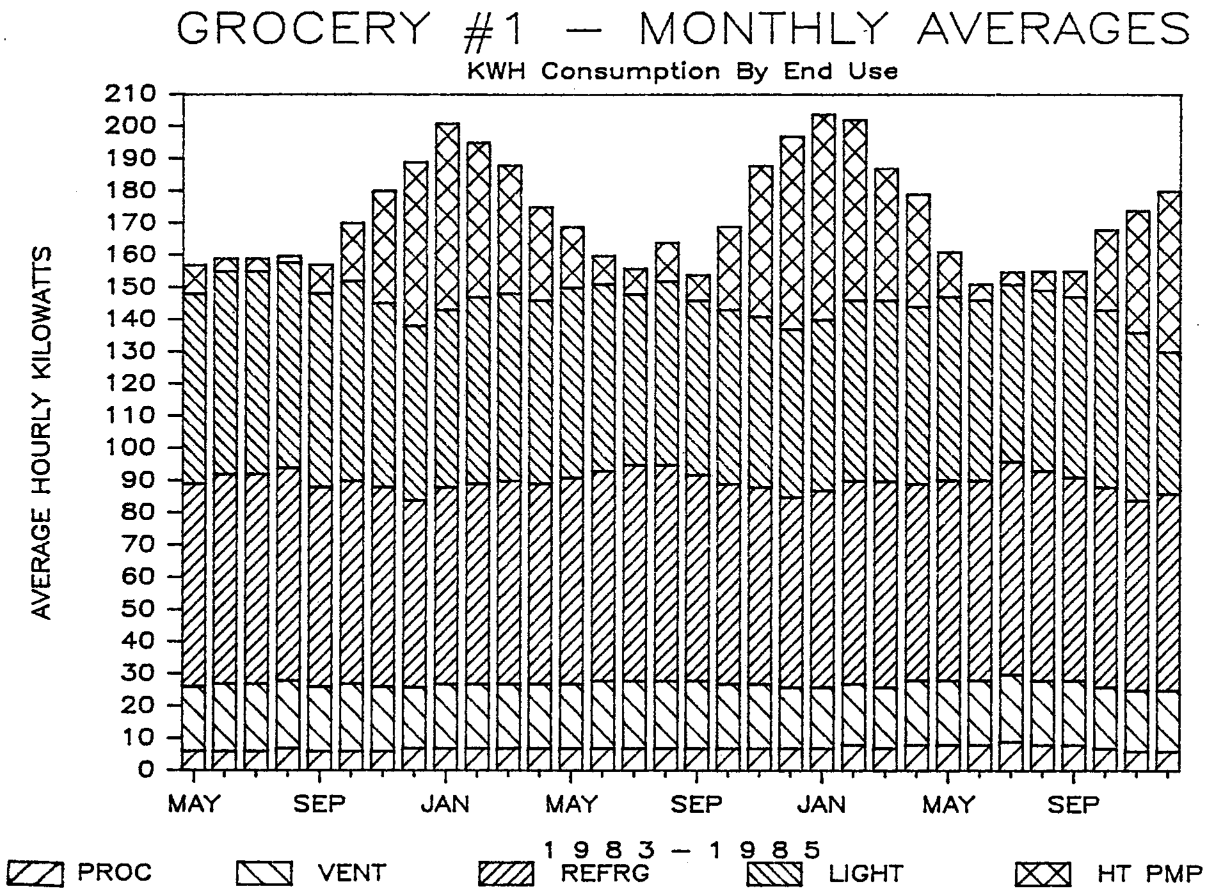
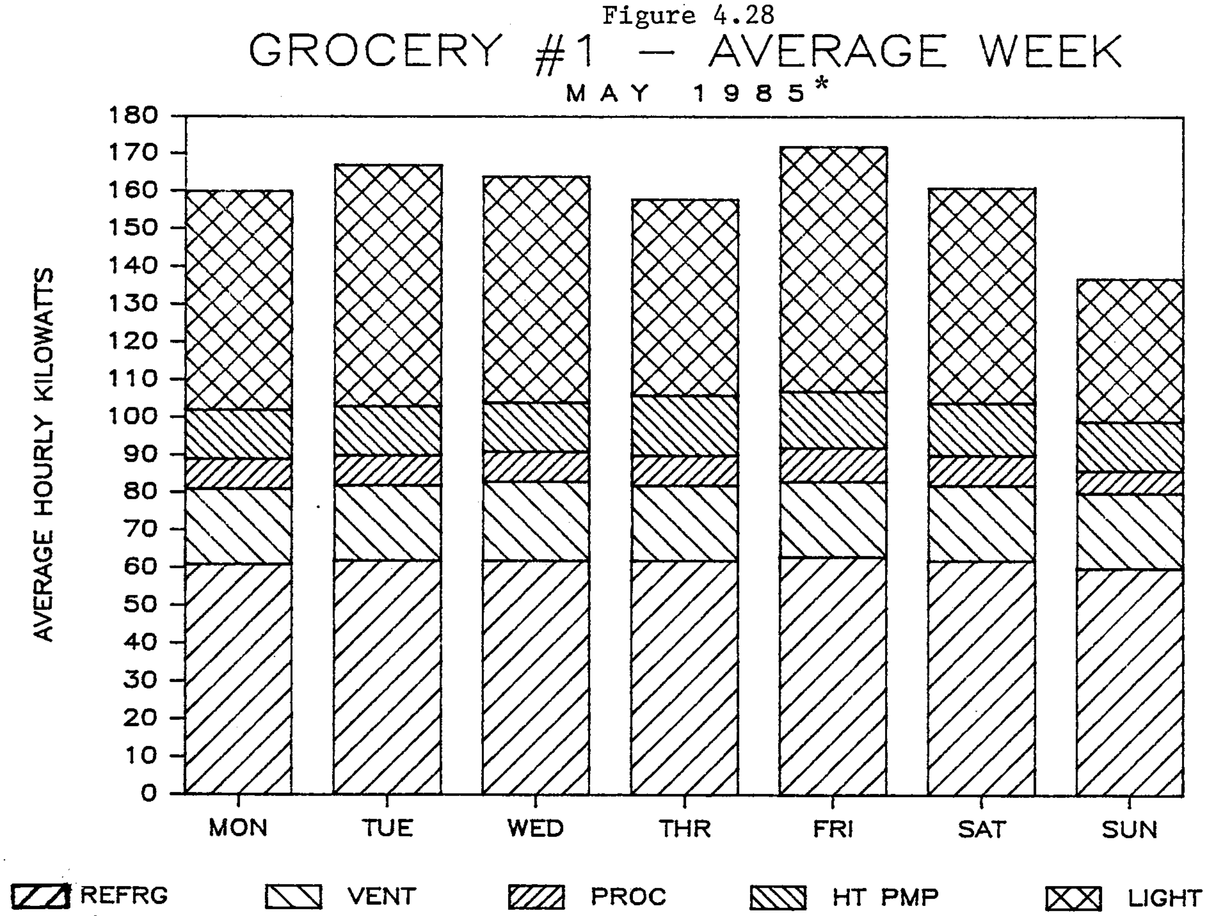
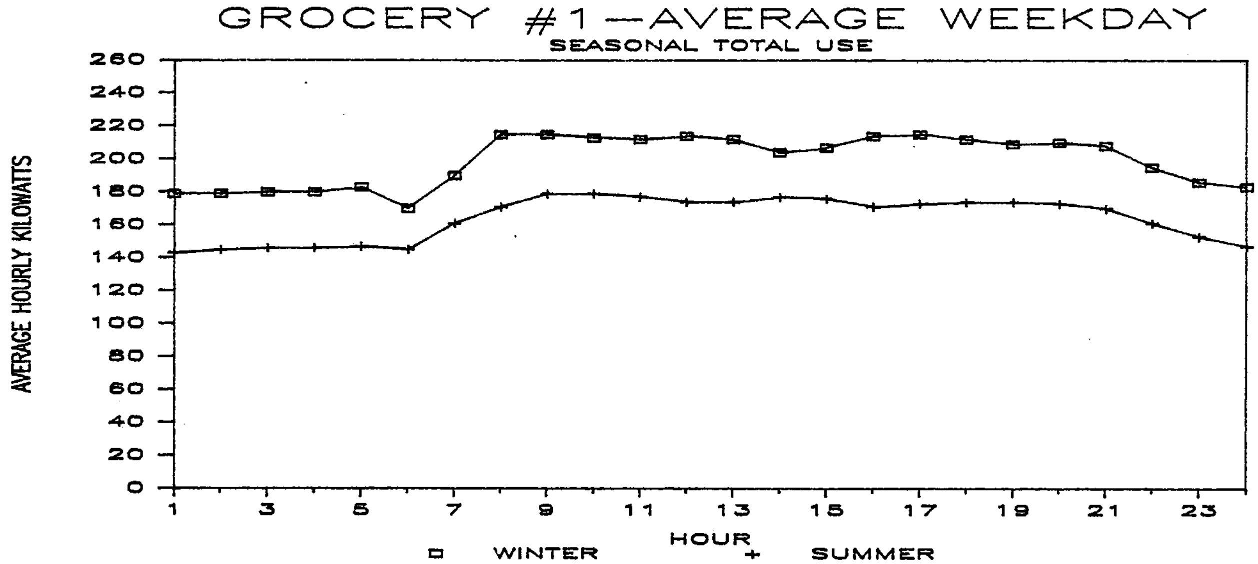


Figure 4.28



*Includes Memorial Day Holiday

Figure 4.29



October '84 - March '85 April '85 - September '85

Figure 4.30

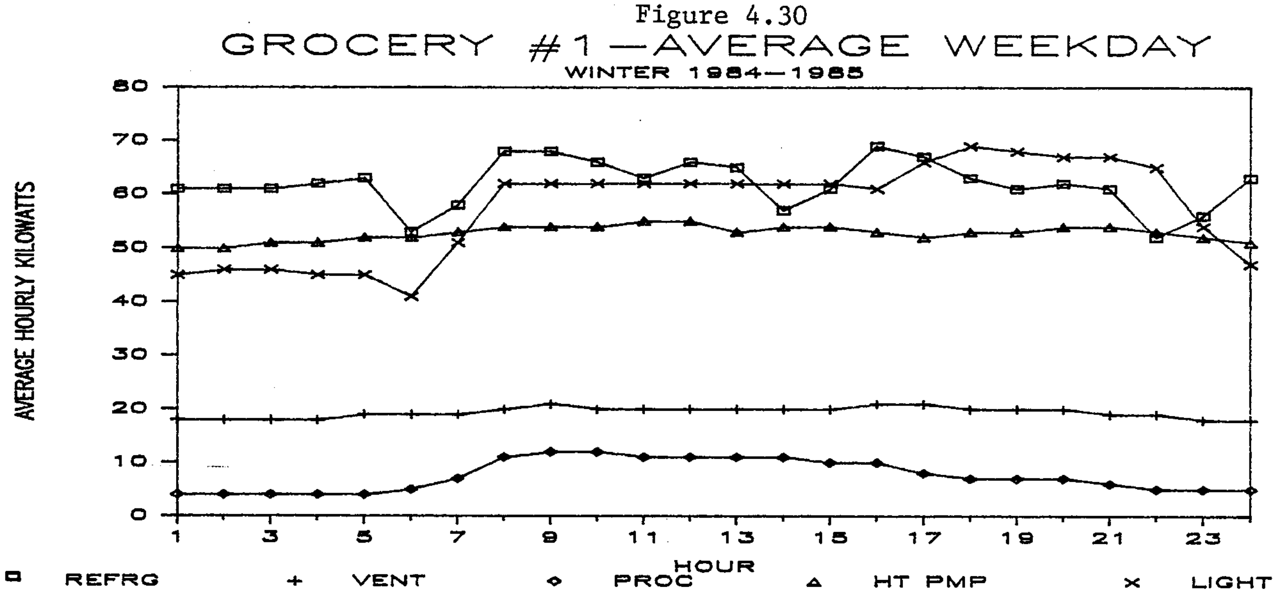


Figure 4.31

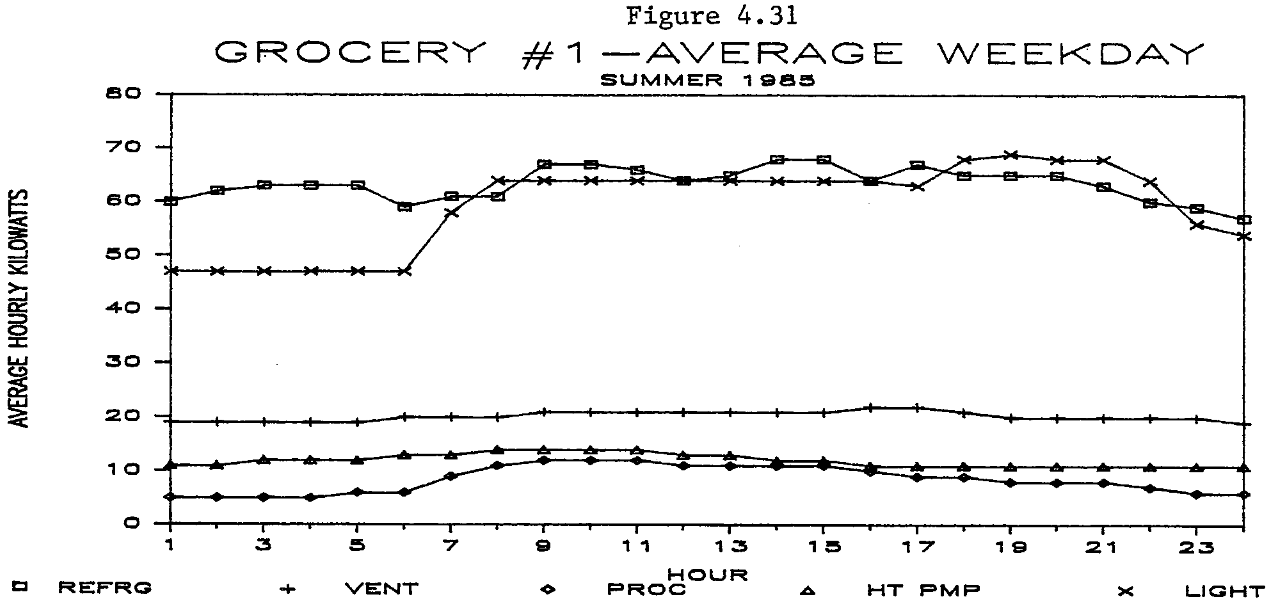
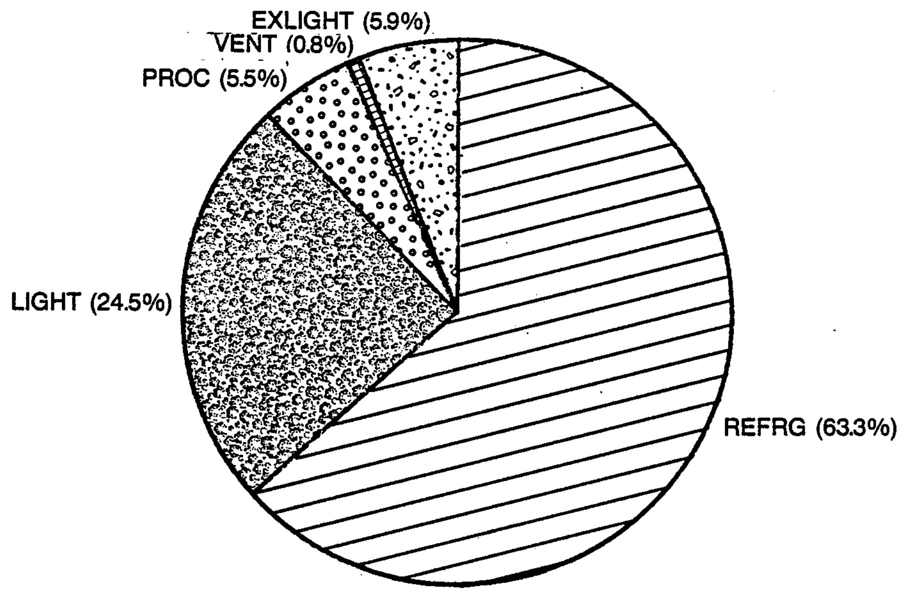


Figure 4.32

GROCERY #2 — ANNUAL ELEC CONSUMPTION

by End Use — 1985



83.9 kwh/sq.ft.

4.3.3.6 Grocery #2

In grocery store #2, as in grocery #1, all of the loads are "on" at relatively constant levels, reflecting the operating characteristics of grocery stores. The difference with this store is that it has gas heat (not graphed), resulting in minimal variation of end-use shares at the monthly level. The total daily consumption does not vary considerably across the days of the week. Summer and winter average weekdays differ slightly due to increased refrigeration load in the summer.

Figure 4.33

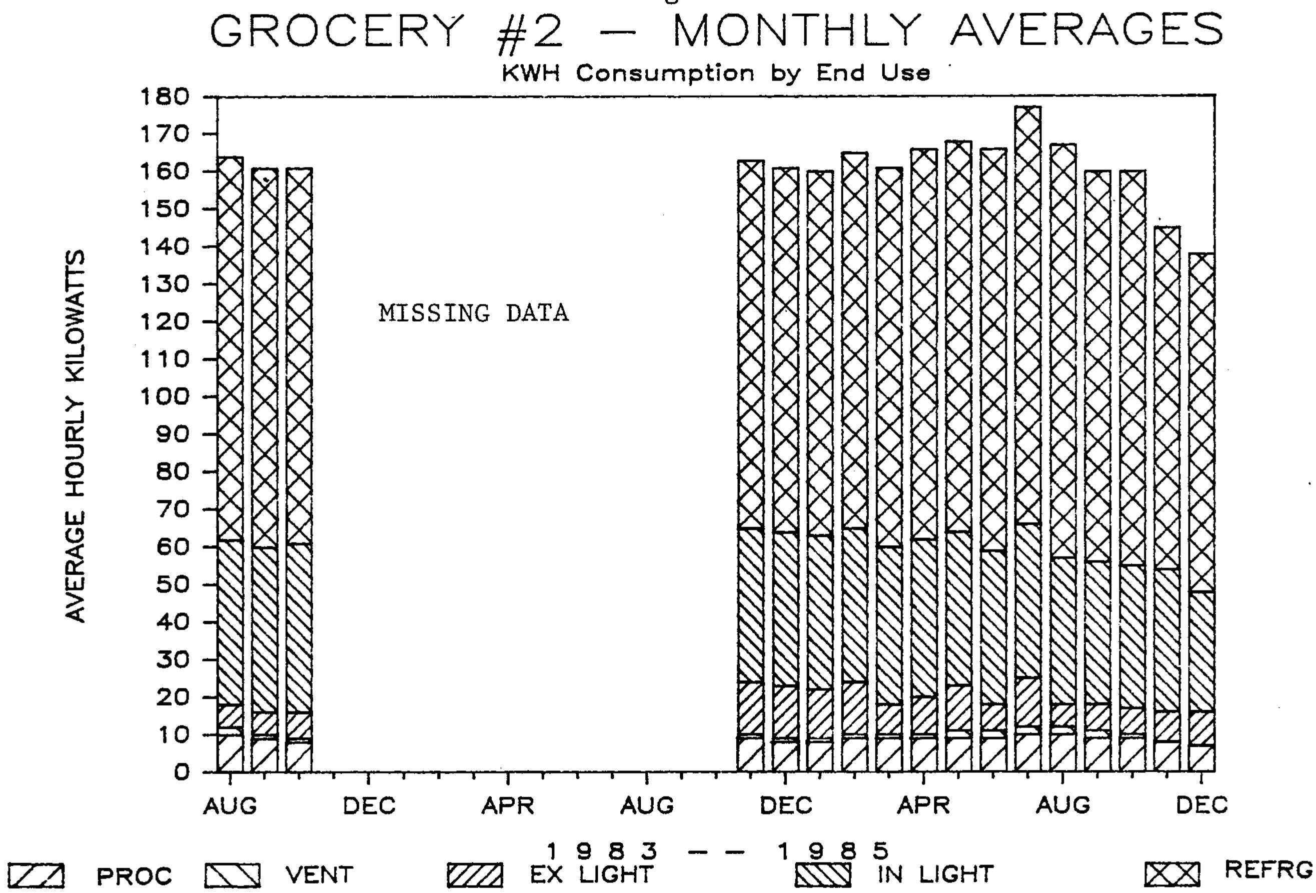
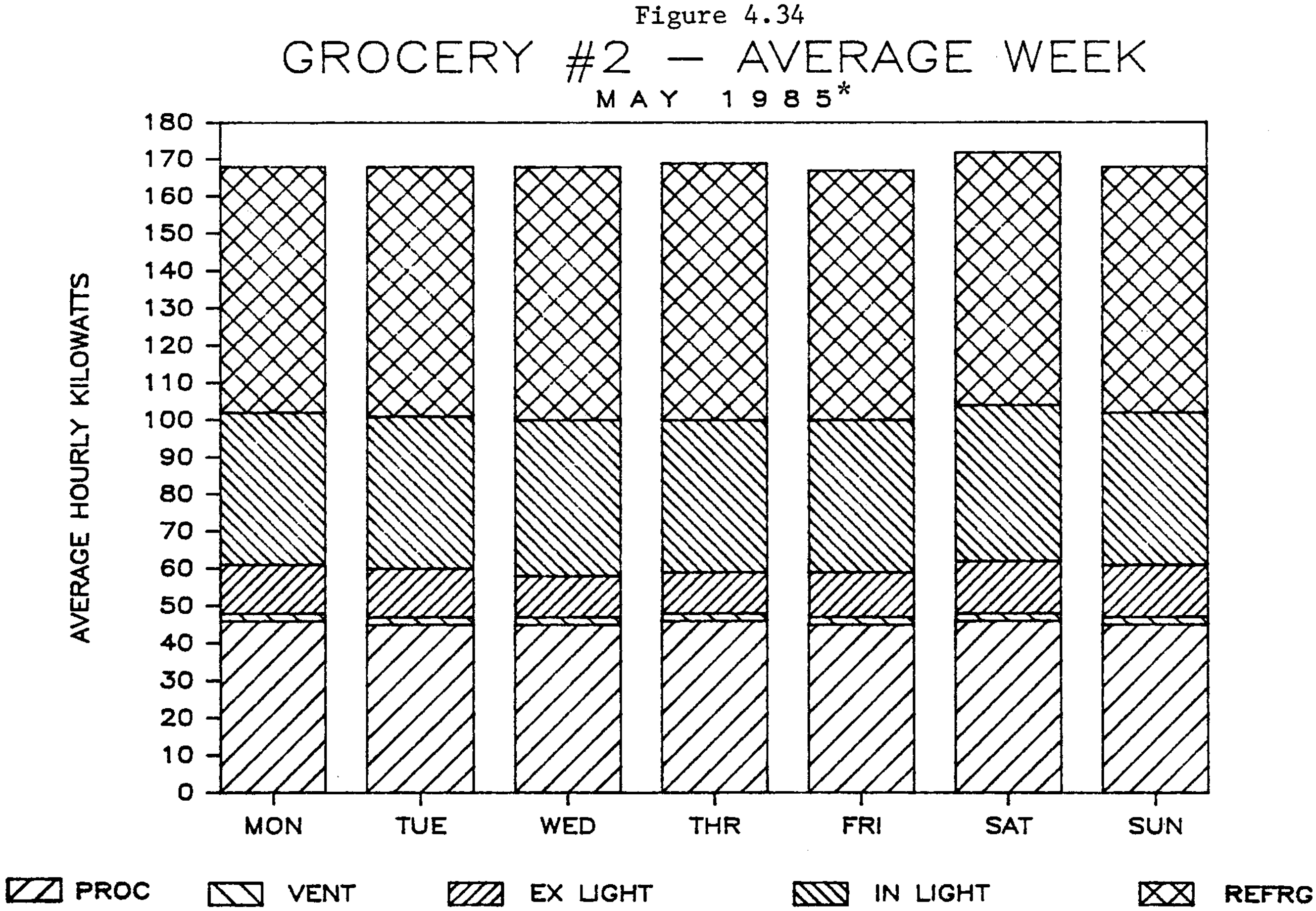
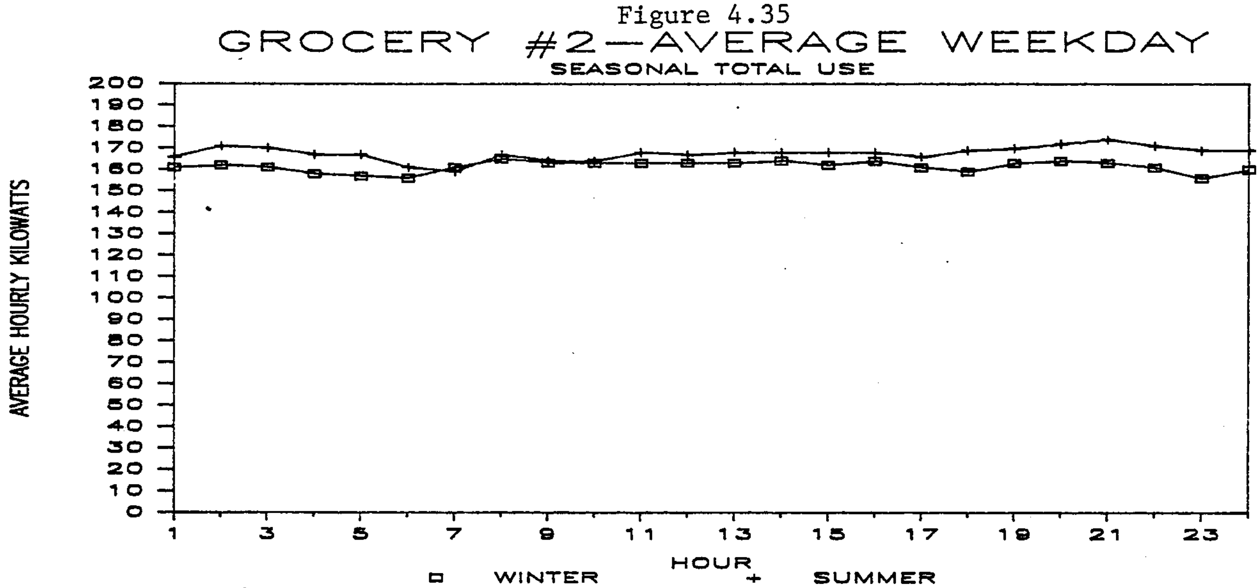


Figure 4.34



*Includes Memorial Day Holiday

Figure 4.35



October '84 - March '85 April '85 - September '85

Figure 4.36

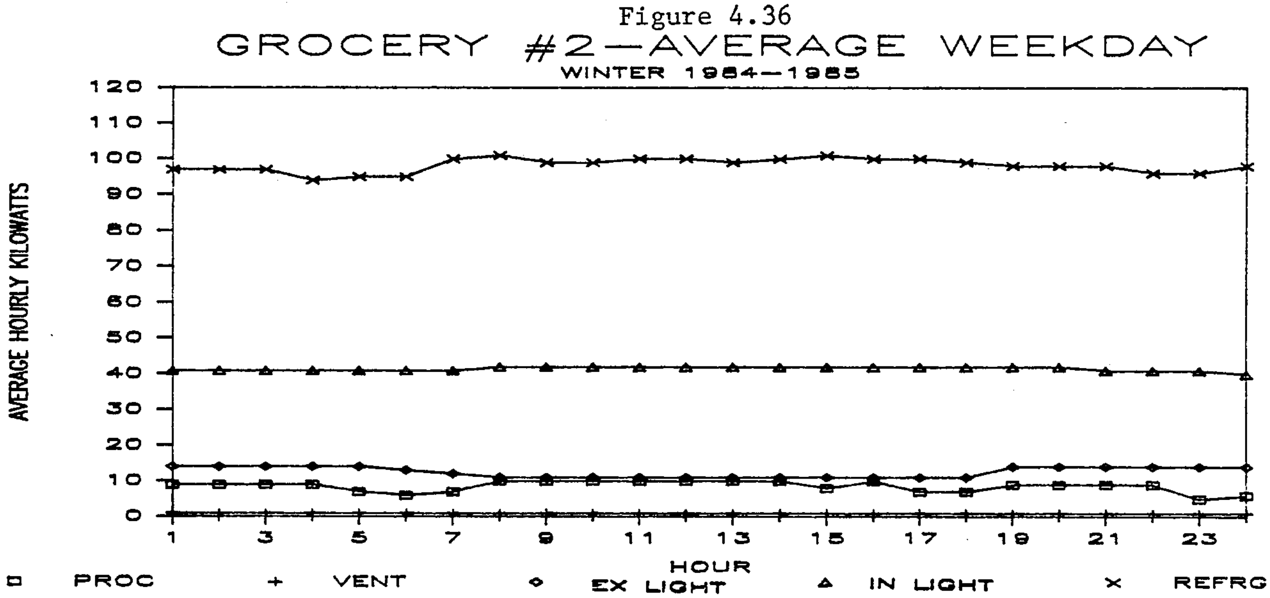


Figure 4.37

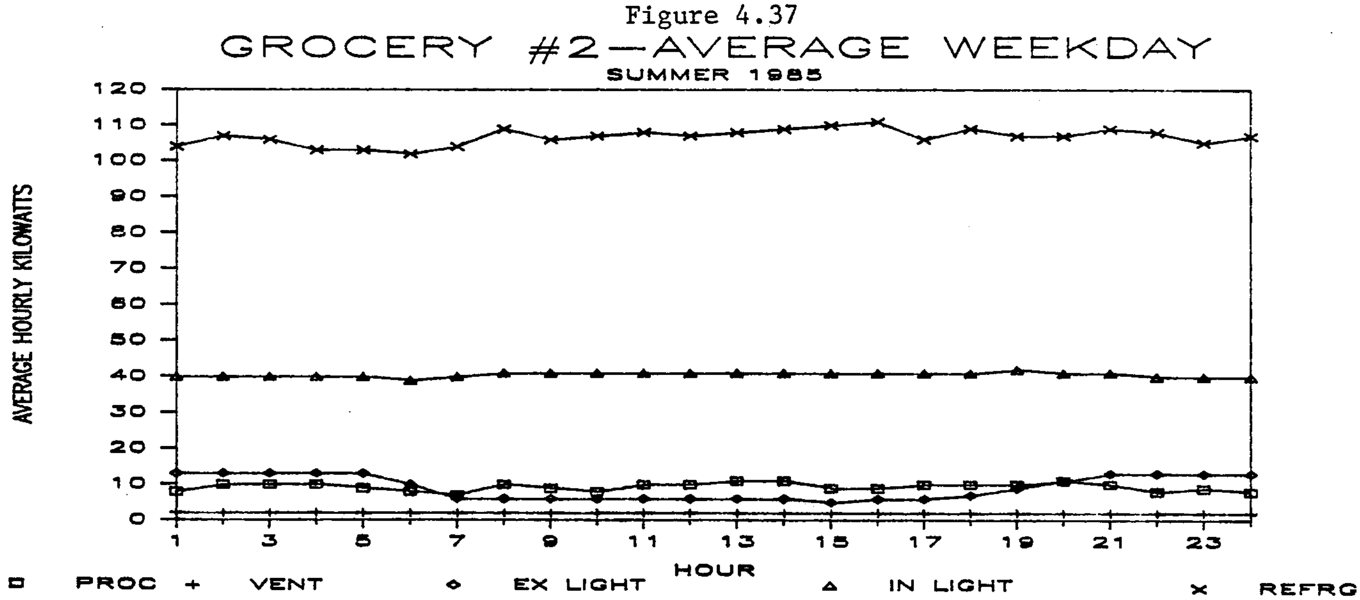
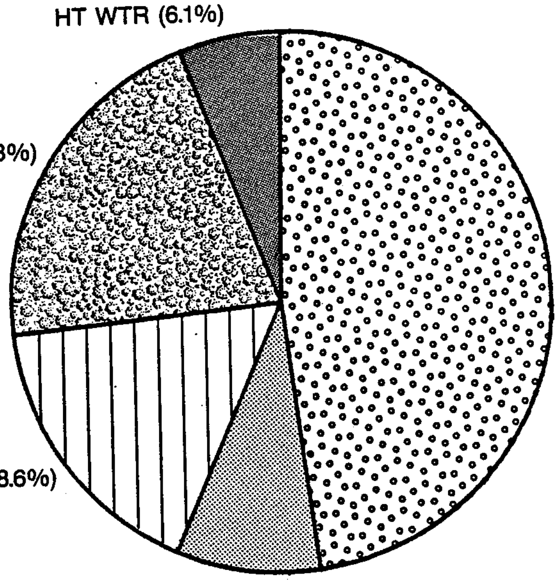


Figure 4.38

RESTAURANT #1 — ANNUAL ELEC CONSUMPTION

by End Use — 1985



107.0 kwh/sq.ft.

4.3.3.7 Restaurant #1

In restaurant #1, at the monthly level of analysis, the end-use shares remain at relatively unchanging levels, with the exception of the cooling load, which comprises a very small part of the building total. The cooling load varies with the season, thus peaking in the summer. At the weekly level there is little end-use share variation, except on weekends for the lighting and food processing equipment loads when the restaurant is open later. The average weekday profiles for winter and summer show quite similar patterns. Lighting and food processing (PROC) loads decrease for only a few hours in the early morning, reflecting the short time the restaurant is actually closed. The processing load is relatively constant throughout the rest of the day, with peaks at lunch and dinner times and operating at higher levels in the summer. Lighting operates at higher levels in the winter due to the store having exterior lighting on for longer periods during the day.

Figure 4.39

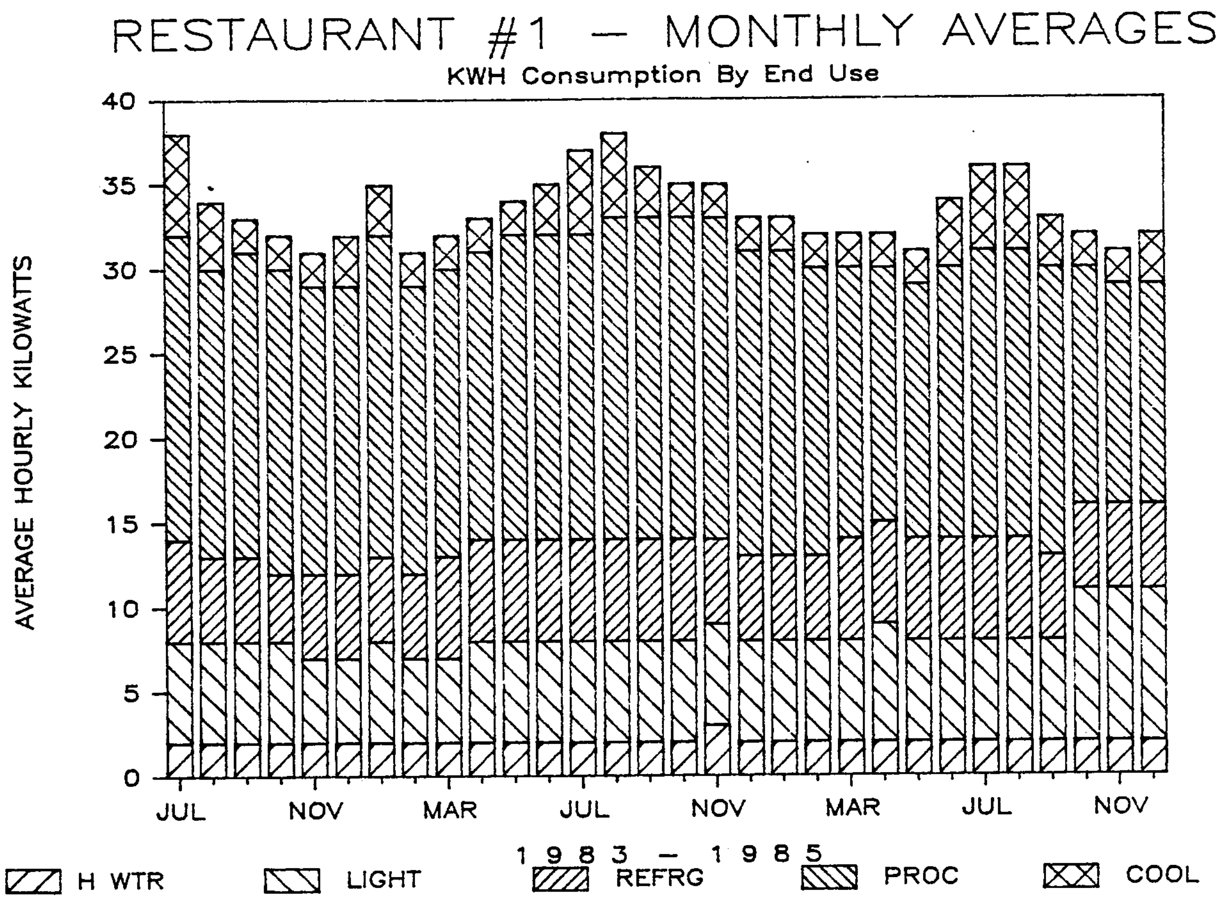
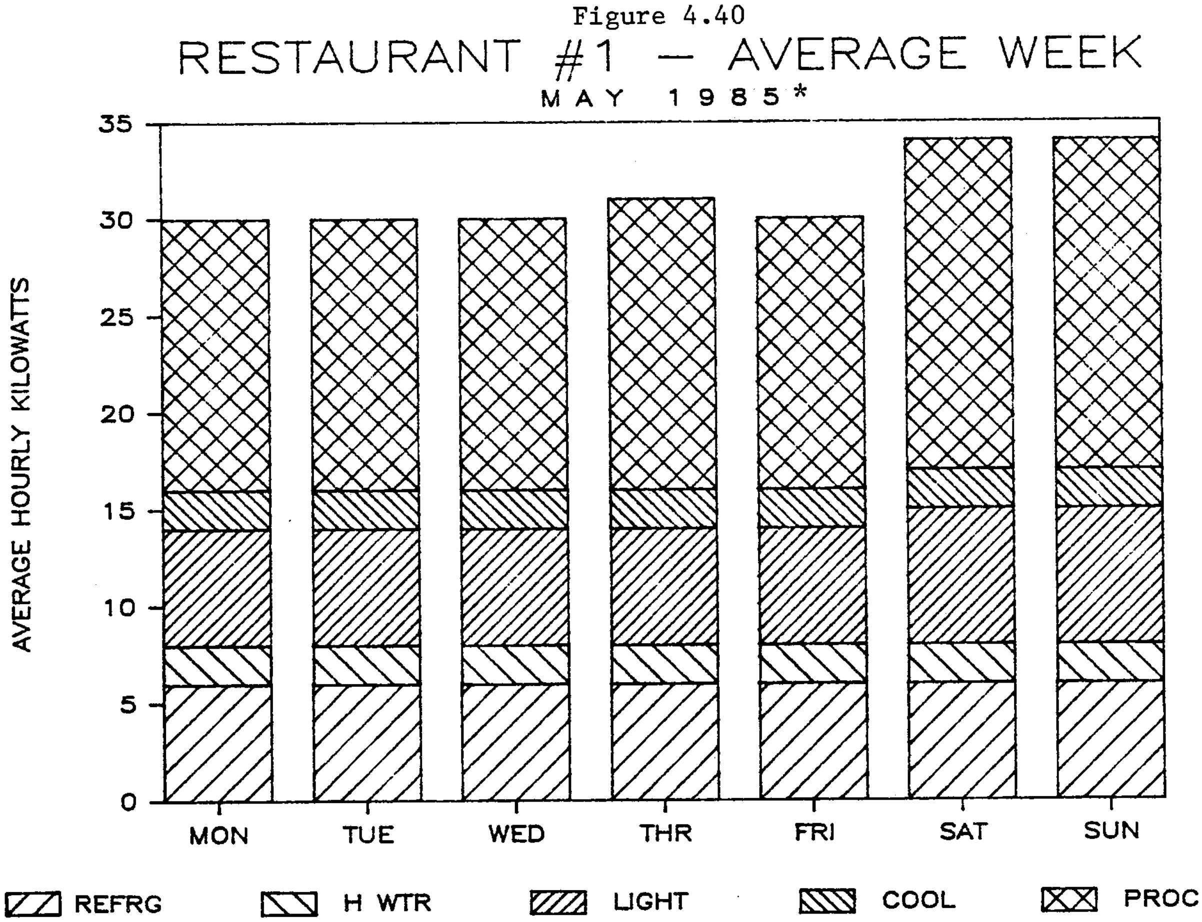
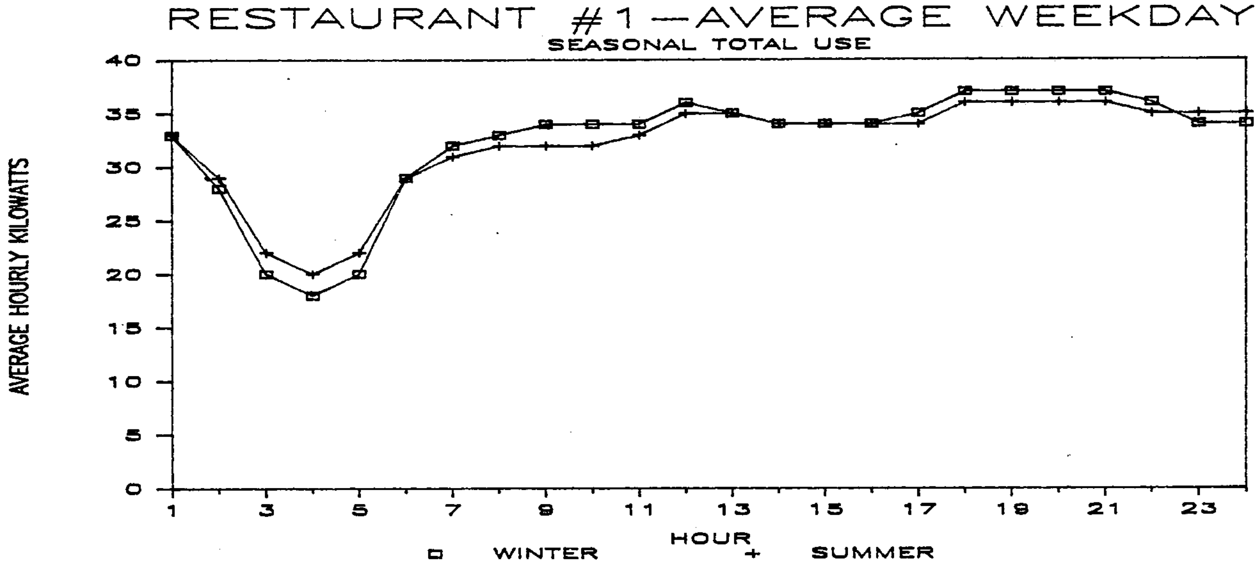


Figure 4.40



*Includes Memorial Day Holiday

Figure 4.41



October '84 - March '85 April '85 - September '85

Figure 4.42

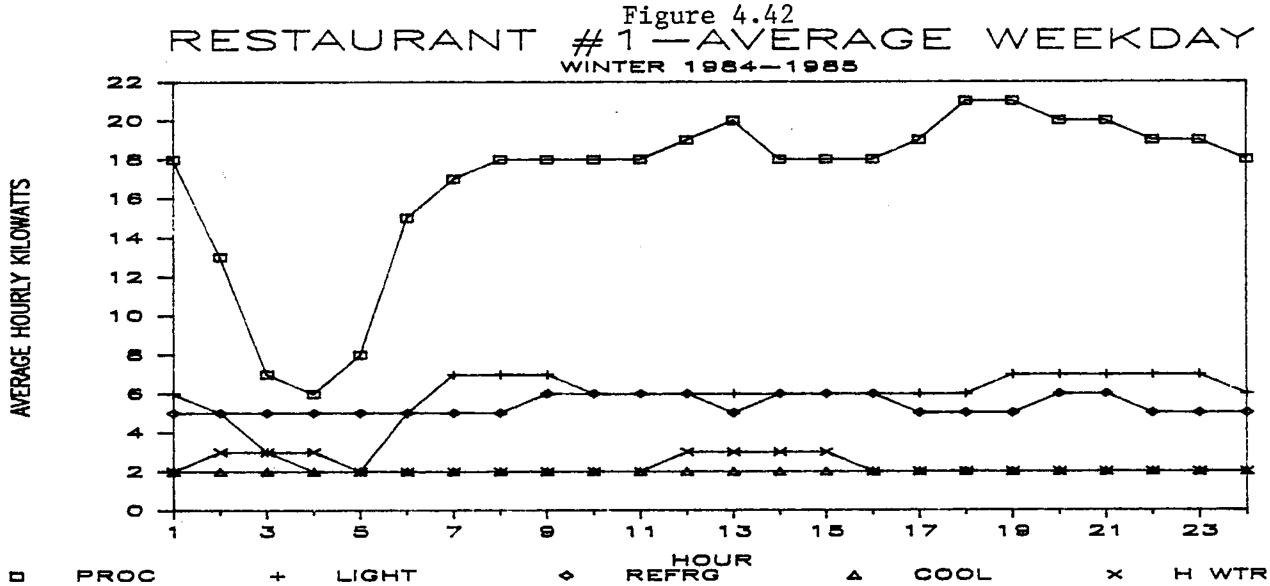


Figure 4.43

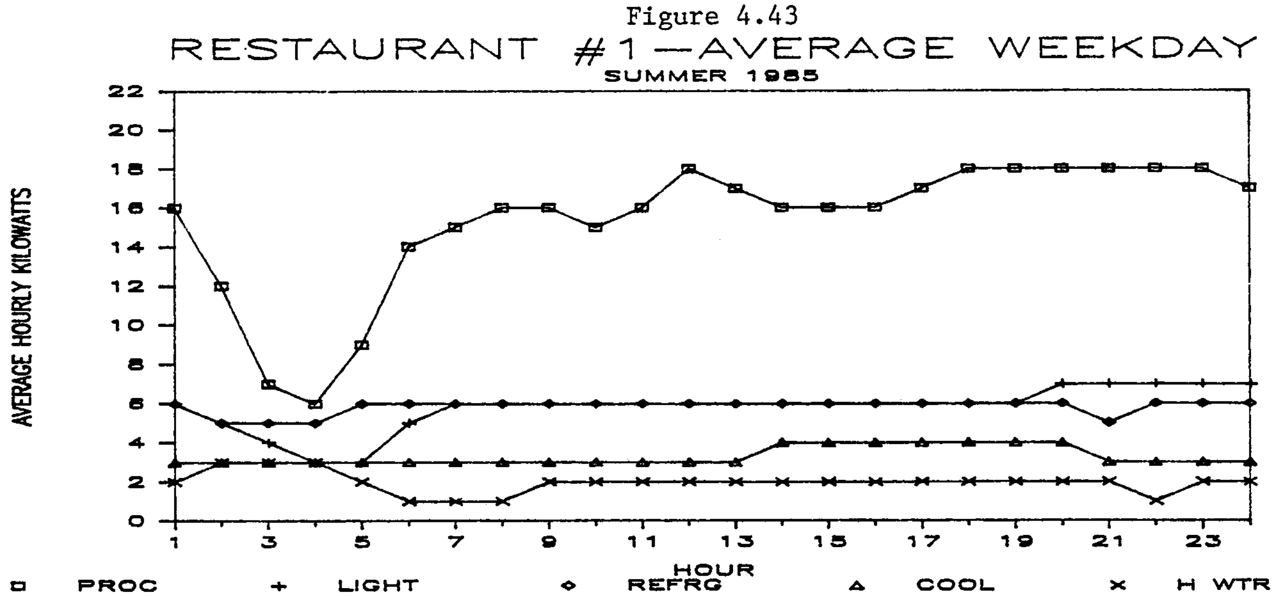
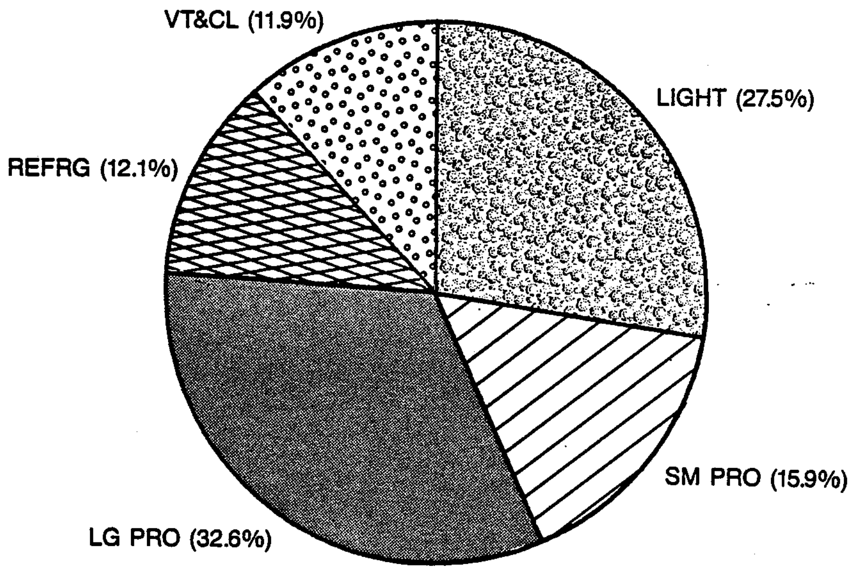


Figure 4.44

RESTAURANT #2 — ANNUAL ELEC CONSUMPTION

by End Use — 1985



105.2 kwh/sq.ft.

4.3.3.8 Restaurant #2

At restaurant #2 there is little fluctuation of end-use shares across the months, with the exception of the seasonal variation in ventilation and cooling (VT&CL) end use. At the weekly level there is little variation across the days of the week. Daily load profiles of average weekdays in the winter and summer show that even though the restaurant is open 24 hours a day, the lighting end use has a distinct daily schedule primarily because the exterior and interior lights are grouped together. Thus, during daylight hours the exterior lights are off and the total light load decreases. Seasonal changes are noticeable in the ventilation and cooling, which in winter operates at approximately 20 percent of its summer level. The large and small food processing (PRO) equipment operate at relatively constant levels with slightly higher levels at mealtimes.

Figure 4.45

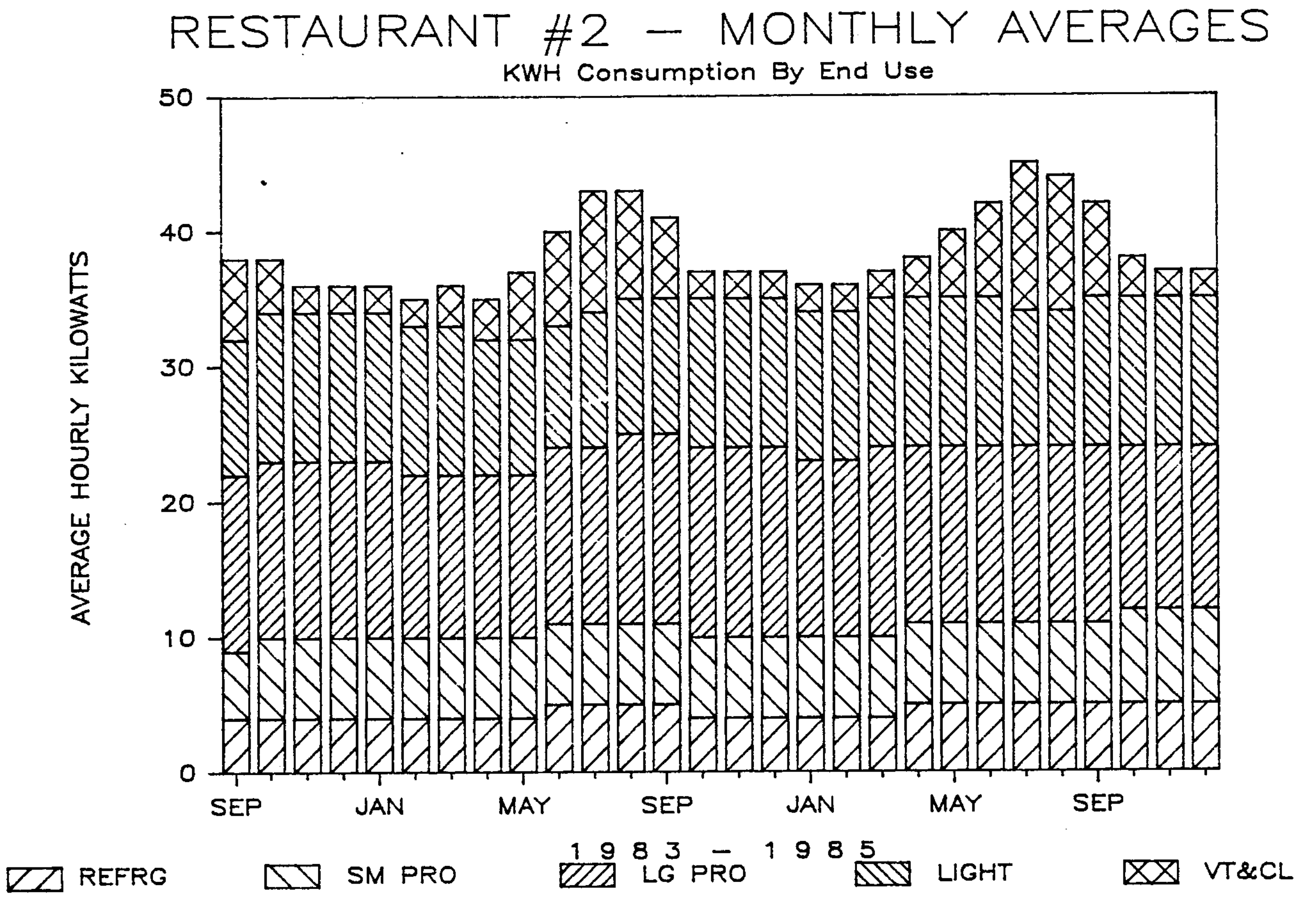


Figure 4.46

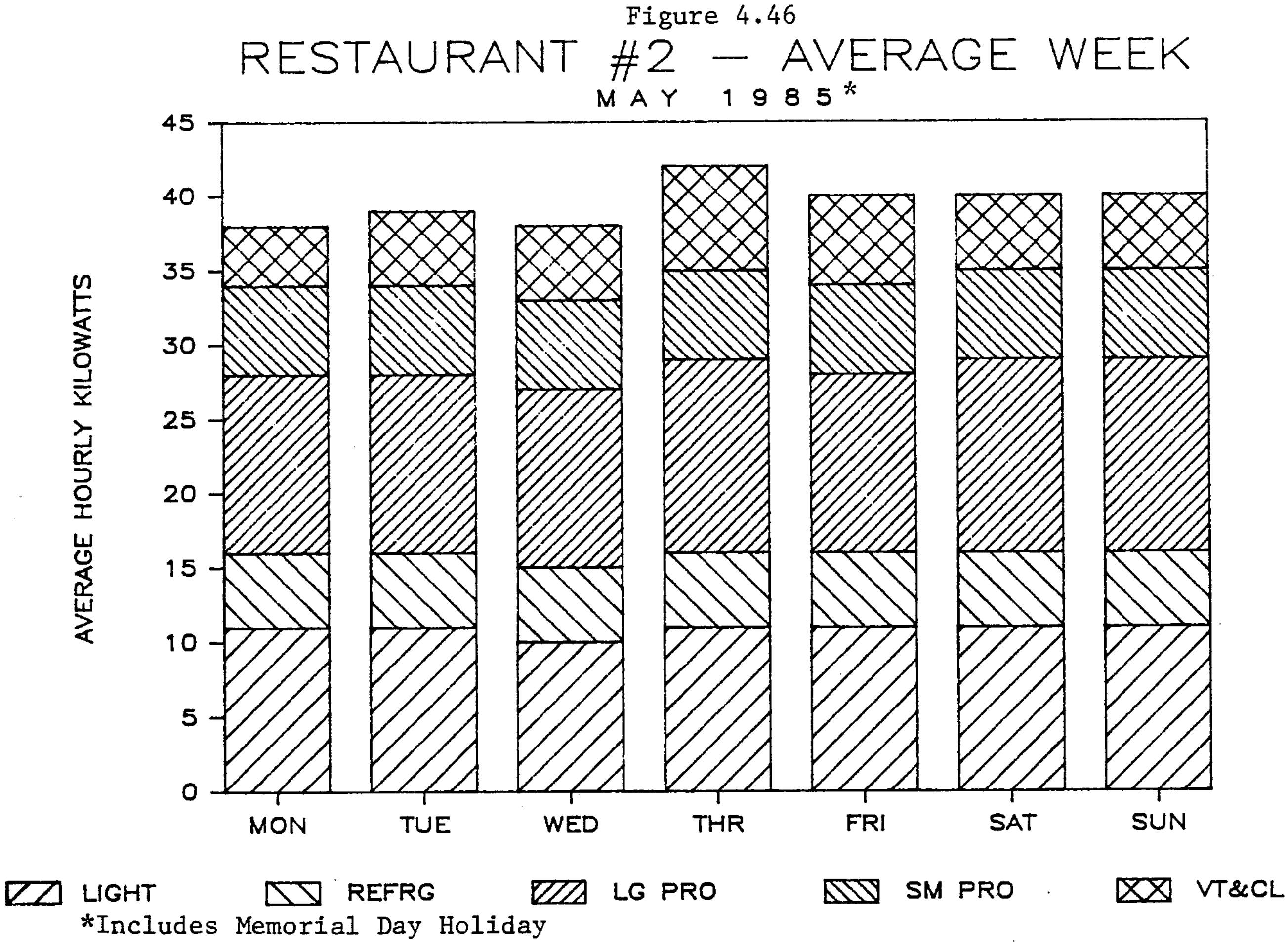
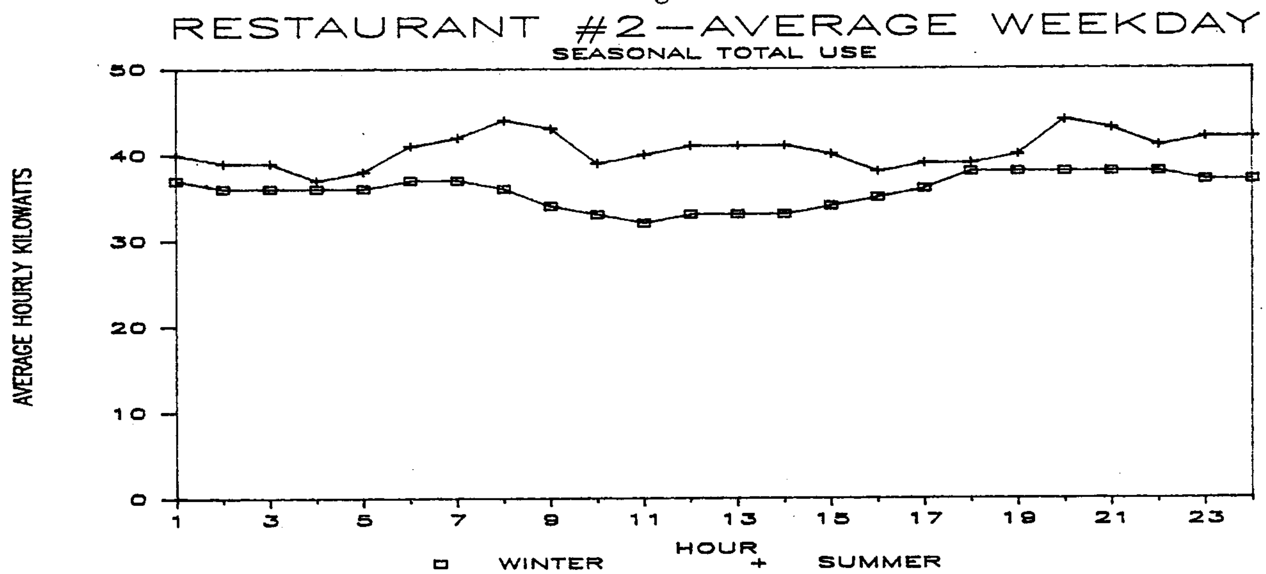


Figure 4.47



October '84 - March '85 April '85 - September '85

Figure 4.48

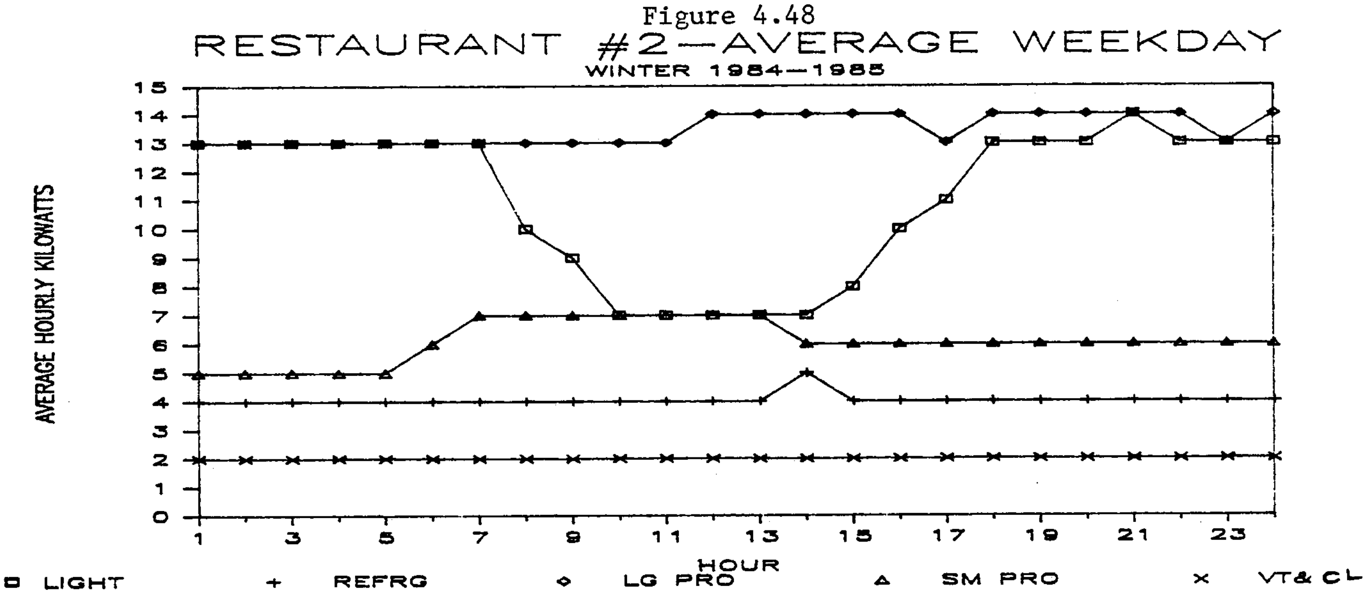
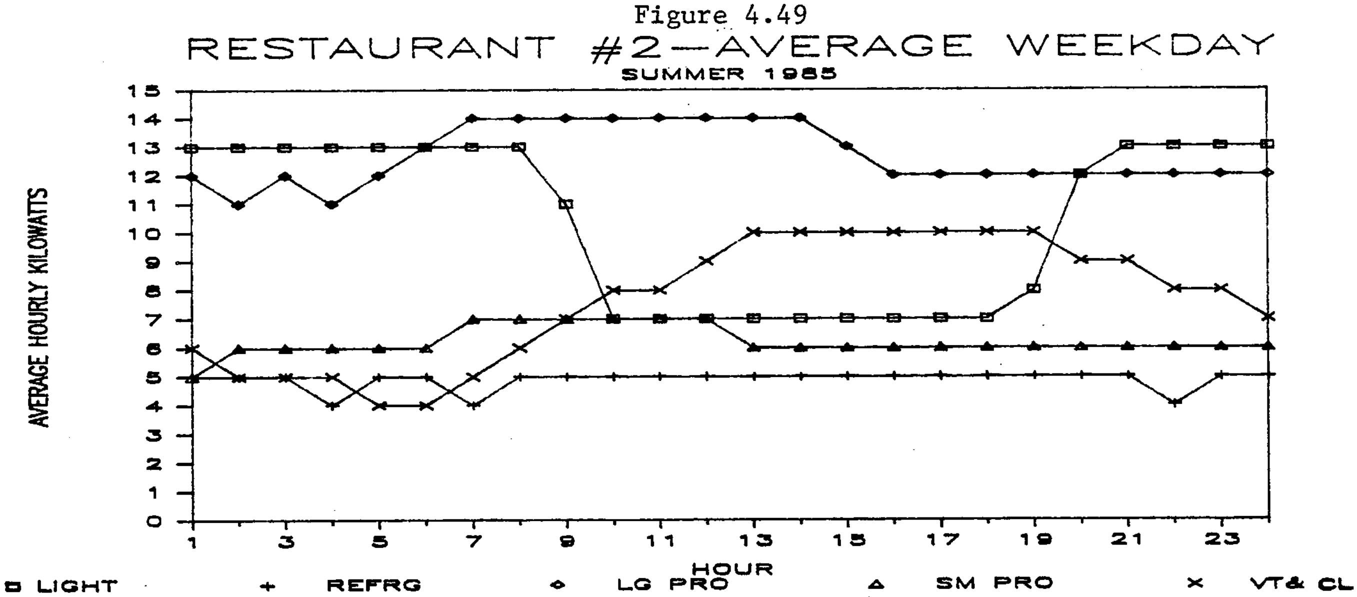


Figure 4.49



4.3.4 Total Energy Consumption Analysis

Since many factors such as principal use and total area influence a building's energy consumption level, comparisons of total energy consumption (electricity and natural gas) can be useful. It is often the case that buildings of similar use and size also have similar total energy consumption levels. Table 4.7 presents the average annual use per square foot for electricity and natural gas in each CHEUS building using the data available from 1980-1983.

Table 4.7

Annual Energy Consumption Per Square Foot*

	Annual Electric Consumption Kwh	Annual Gas Consumption Therms	Consumption/ sq.ft		Total Consumption/sq.ft.	
			Kwh	Therms	Btu Thousands	Kwh
Retail #1	719,000	-	32.2	-	110	32.2
Retail #2	680,000	12,178	18.5	0.33	96	28.2
Office #1	2,063,000	-	23.0	-	79	23.0
Office #2	314,000	-	21.0	-	72	21.0
Grocery #1	1,455,000	-	58.7	-	200	58.7
Grocery #2	1,499,000	7,130	88.9	0.42	345	101.2
Restaurant #1	322,000	7,405	129.5	2.97	738	216.5
Restaurant #2	327,000	29,680	100.5	9.13	1,256	368.1

*Four-year average (1980-1983).

Certain patterns emerge. No two buildings within a given building-type category consume the same amount of energy on a per-square-foot basis. The largest differences in total energy consumption per square foot are noted in the grocery and retail categories. Differences between the buildings in each category are probably related to specific characteristics of these particular buildings. The higher consumption level of retail #1 may be due to year-round use of the ventilation and air-conditioning systems during the four-year period 1980-1983. Retail #2 only uses fans as a cooling system during the summer months. It is surprising to note how close the consumption levels are for the two office buildings because office #1 is nearly six times the size of office #2. In comparing the grocery stores, the larger store, grocery #1 (25,000 sq.ft.), is nearly half the consumption level of the smaller grocery #2 (16,000 sq.ft.) on a total energy use per-square-foot basis. Three reasons account for the higher energy intensity of the smaller, second store. First, the lighting levels are higher in grocery #2. Second, grocery #2 has more refrigerated cases than grocery #1. Third, grocery #1 has a heat pump. The difference in use per square foot observed between the two restaurants is perhaps due to the fact that restaurant #2 is a 24-hour coffee shop while restaurant #1 is a fast-food business open 103 hours a week. However, restaurant #1 uses more electrical equipment for cooking than does restaurant #2.

Chapter 5

CONSERVATION ANALYSIS

5.1 Simulation Methodology

The analysis of the energy consumption of all eight buildings followed a three-step process:

5.1.1 Develop Base Case Development

The first step involved the creation of a base case simulation of consumption using the DOE 2.1A simulation program. The simulation utilized the building characteristics data collected during the audit and the hourly end-use load data obtained from a microprocessor system installed by City Light. A "constrained" DOE 2 model was developed by using the the hourly consumption data to determine the annual schedules for various non-HVAC end-use loads including lighting, equipment, hot water consumption, etc. This energy analysis was conducted using Sea-Tac weather data for the time period June 1981 through June 1982. The base case simulation was considered to adequately characterize consumption when the simulation results matched the actual 1981-82 monthly energy bills within ±15 percent.

5.1.2 Estimate Conservation Costs and Energy Savings

The second step of the analysis involved estimating the benefits and costs of a practical set of conservation measures. Each measure was considered individually for its thermal performance in the DOE 2.1A simulation program utilizing typical meteorological weather for the Seattle area. Modifications were made to the base case to include operation and maintenance measures and low-cost and no-cost conservation measures. As a result, the energy savings and cost-effective analysis assumed that the low-cost and no-cost measures were conducted first. The economic analysis for each strategy was performed by City Light's life-cycle cost analysis computer program. This program calculates the value of energy savings based on the marginal cost of supplying energy. It is expected that the regional marginal resources will be a combination of gas turbines and a coal plant. Hence, the value of the incremental cost to the region of new fossil-fueled generating facilities is termed marginal thermal value (MTV). City Light's planning efforts value conservation savings at the marginal thermal value because it is assumed that these energy savings will result in less thermal generation built or acquired by the region to meet future demand.

A measure was considered to be cost effective when the present value of the energy savings to City Light over the life of the project (using marginal thermal value of energy - MTV) was greater than the total present value of the costs of the measure. Costs included capital purchase, installation charges, and operation and maintenance. Only measures that were practical to retrofit were considered in this analysis.

5.1.3 Specify Cost-Effective Conservation

The third and final step of the conservation analysis involved specifying an optimum set of conservation measures. Assuming that the most cost-effective measure would be implemented first, the base case was modified accordingly and the impact of the measure was simulated. Then the base case, modified with the first measure, was used to evaluate the incremental gains in energy savings and costs obtainable from each of the remaining measures. The remaining measures in combination with the first measure were reordered in rank of cost effectiveness. If the thermal and economic analyses of each remaining measure run separately in combination with the first measure were not cost effective, the measure was eliminated from further consideration.

Then the combination of the first and next most cost-effective measure was used to evaluate the savings obtainable from the remaining measures. The twice-modified base case was simulated with the remaining measures separately to find the most cost-effective combination of three measures. This procedure was repeated until the optimum set of measures was found. Thus, this final set includes all measures that were cost effective in combination with each other.

5.2 Management of the Computer Simulation Work

Simulation and evaluation of multiple conservation strategies are possible with a specially developed computer program, DEMON, which assists engineers and policy analysts in the management of numerous computer-related tasks. In general terms DEMON can be thought of as a file manager. It stores and keeps a directory of building descriptors; stores billing, square footage, and rate data; submits batch jobs; tracks DOE 2 simulation runs and strategies associated with different buildings; and performs life-cycle cost analysis. DEMON's major function is to facilitate the comparison of output data from multiple DOE 2 runs. It is able to keep simulation runs separate as well as match up relevant ones.

The original DEMON program developed in 1983 was revised in 1985. The 1985 DEMON is more "user friendly," including its own internal editing features. Users need little computer training to operate DEMON effectively. DEMON has largely automated the process of simulating a building's energy consumption because the program's file management capabilities have greatly simplified the processing of multiple energy consumption simulations.

5.3. Simulation Costs

The simulation analysis for all eight buildings was performed by United Industries Corporation, an engineering consulting firm. Technical review was performed by City Light commercial auditors. The labor costs for the simulation work included auditing the facility, developing a base case that matched monthly utility bills, analyzing alternative conservation strategies, and identifying an optimum package of measures. A maximum of $12,000 per building in labor charges was paid for these services. In addition an average of $2,700 per building in data processing charges was assessed for the simulation runs. The data processing charges varied among buildings primarily due to the number of strategies analyzed.

These costs are close to levels for similar work underway in the Pacific Northwest region. Another engineering consulting firm estimates, from its experience, that for similar work the costs range between $10,000 and $13,000 per building. The maximum allowable limit for simulation work under a current BPA program for Institutional Buildings (IBP) is 1.08 cents per annual kilowatt of consumption. For City Light study buildings, this limit would range from $5,300 for the smaller buildings to $34,000 for the large complex building. The average allowable limit for the all eight buildings under IBP guidelines would be around $17,000 per building.

5.4. Conservation Analysis Findings

The analysis of the conservation potential of the eight CHEUS buildings have involved monitoring hourly end-use loads, performing audits, and identifying cost-effective conservation measures through computer simulations. This work has provided insight into the energy consumption of and conservation opportunities for these buildings. A comparison of these results with City Light's estimates of consumption and conservation potential of the commercial sector before this study began provides an opprotunity to reassess the earlier assumptions.

5.4.1 Conservation Potential Assessment

In 1982 City Light assessed the conservation potential in its residential, commercial, and industrial sectors for the purpose of identifying conservation savings beyond those estimated in the long-range forecast of electricity demand. The load forecast includes conservation from City Light-sponsored programs and from actions customers take on their own in response to rising energy costs. Through the Conservation Potential Assessment (CPA), City Light established a target of conservation savings through year 2002 to guide the planning of new conservation programs. The CPA estimated baseline consumption levels for existing and new construction for residential, commercial, and industrial customers and developed estimates of the conservation potential in each sector. The 1982 CPA was a comprehensive study to estimate the electrical conservation potential in City Light service territory over the next 20 years.

The building prototypes used in the CPA were not actual buildings. The differences between the CPA estimates and the findings from the CHEUS buildings reflect the difference between the prototype building analysis and analysis on actual buildings where simulated consumption was matched to monthly utility bills. Because the CPA was limited in the number of prototypes developed, comparisons can be made only for office and retail buildings. While there are only two CHEUS buildings in each building category, these comparisons with the CPA place the CHEUS findings in perspective. No comparison with the CPA results is provided for the grocery and restaurants because these building types were not included in the CPA analysis.

In 1985, the City Light Conservation and Solar Division developed a Commercial Retrofit Measures Spread Sheet (CRMS) to assess the conservation potential of the commercial sector for City Light's Strategic Resources Plan. While the spread sheet/CRMS does not replace the CPA, it serves to update the consumption and saving estimates for the commercial sector. In CRMS the consumption estimates are based on the 1984-85 forecast information, and the conservation estimates include applicable commercial building measures and saturation rates for each building type. Following the discussion of CPA and CHEUS comparison for office and retail buildings, a short description of the CRMS estimates is given below. While these comparisons are not conclusive, as the CHEUS findings are based on only two study buildings for each building type, such comparisons are useful as they provide insight to the numbers representing the sector as a whole.

5.4.2 Office Buildings

Building Descriptions. The first CHEUS office is a large, 90,000-sq.ft. building, six stories tall. CHEUS office #2 is a smaller, 15,000-sq.ft., three-story building with a parking garage on the first floor. The CPA office building prototype, however, was much smaller than the CHEUS buildings--a 4,000-sq.ft., two-story office building.

Office Building Consumption. Table 5.1 compares the consumption assumptions used in the 1982 CPA with data collected from the two CHEUS office buildings in 1983-84. These comparisons are displayed in Figure 5.1. This information provides an opportunity to see how the actual building consumption for two buildings differs from the prototype used to represent the sector in the 1982 CPA.

Table 5.1

Office Building Electrical Consumption
(kwh/sq.ft./year)
(Btu/sq.ft./year in thousands)

	HVAC	(%)	Lights	(%)	Other	(%)	Total
CPA - Office*	16.3		11.2		2.8		30.3
	55.6	(54)	38.2	(37)	9.6	(9)	103.4
CHEUS**							
Office #1	7.2		5.2		2.7		15.1
	24.6	(48)	17.7	(34)	9.2	(18)	51.5
Office #2	8.0		5.9		3.2		17.1
	27.3	(47)	20.1	(35)	10.9	(18)	58.3

*1982 CPA, page 4-3.
**1985 hourly end-use data.

The measured consumption of the two CHEUS office buildings on use per square foot is one-third lower than the CPA estimate for the prototype office building. However, a fairly close match in the distribution of the end-use loads can be seen. In all three cases HVAC loads are half of the total load, with lights and other equipment making up the other half. However, the heat portion of HVAC differed between the prototype used in the CPA and the two CHEUS buildings. In the CPA estimate, heat was 70 percent of the HVAC load (38 percent of total load), compared with only 40 percent of the HVAC load (20 percent of total load) estimated for heat in the CHEUS office buildings.

While these are comparisons with only two or three office buildings, the value of an accurate assessment of baseline consumption can be seen. An overestimation in the overall consumption level and/or in the end-use shares of total consumption can affect estimates of conservation potential, as discussed next.

Conservation Measures for Office Buildings. The CPA identified six cost-effective measures through simulation work. The measures were typical residential measures: (1) temperature setback, (2) wall insulation, (3) ceiling insulation, (4) efficient lighting, (5) infiltration control, and (6) storm windows. Due to resource and time constraints for the preparation of the CPA, these measures were regarded as proxies for commercial measures. Figure 5.2 indicates that 30 percent of the energy savings identified in the CPA were expected from lighting measures, while HVAC-related measures accounted for the remaining savings. The information for the two CHEUS office buildings shows a different split of the energy savings. Half of the energy savings for CHEUS office #1 is from lighting conservation measures, compared with 40 percent of the savings from lighting measures in CHEUS office #2. In both CHEUS cases, lighting and HVAC controls accounted for the majority of the energy savings, rather than shell improvements.

Figure 5.1

OFFICE BLDG. END USE CONSUMPTION

All Electric

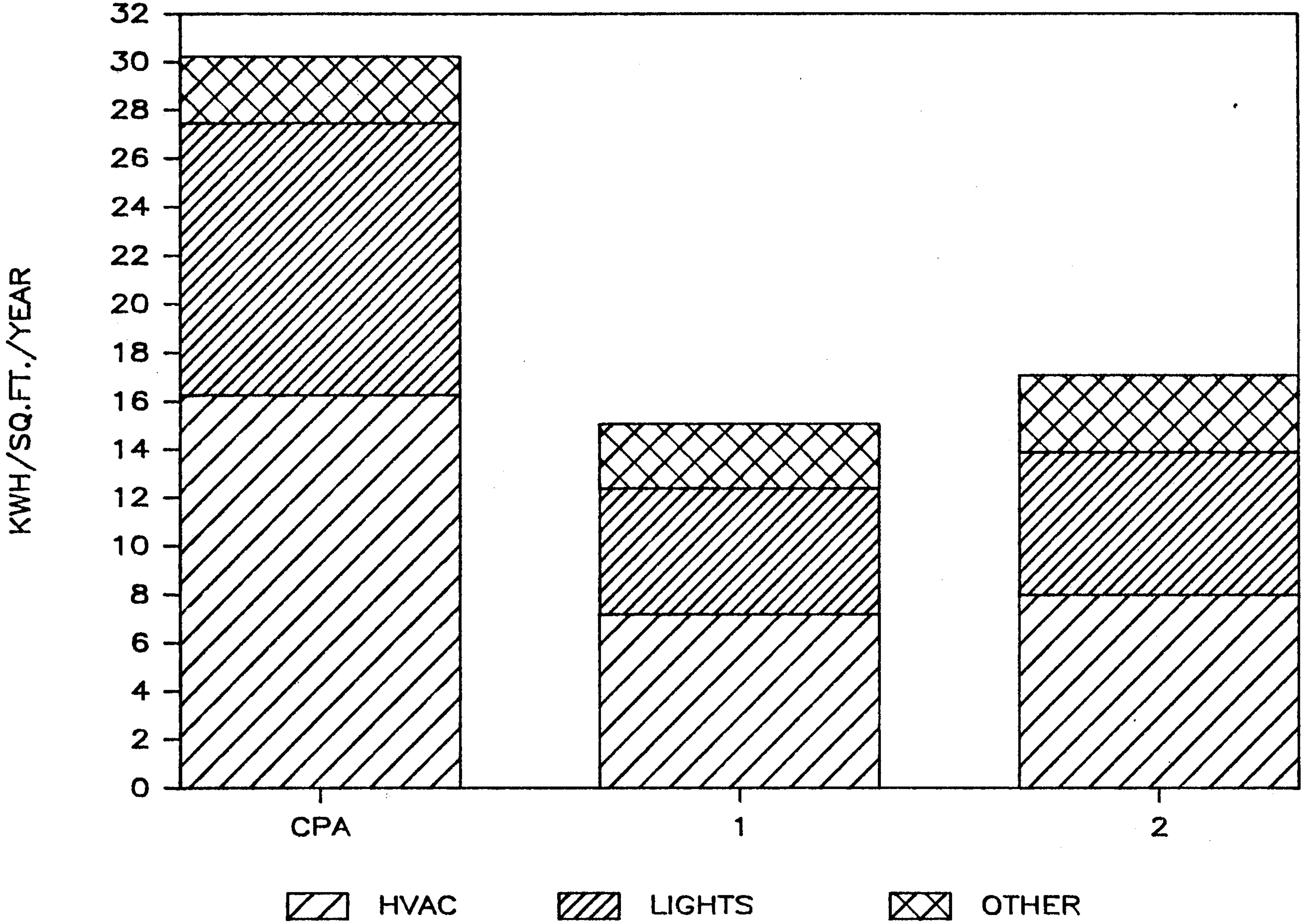
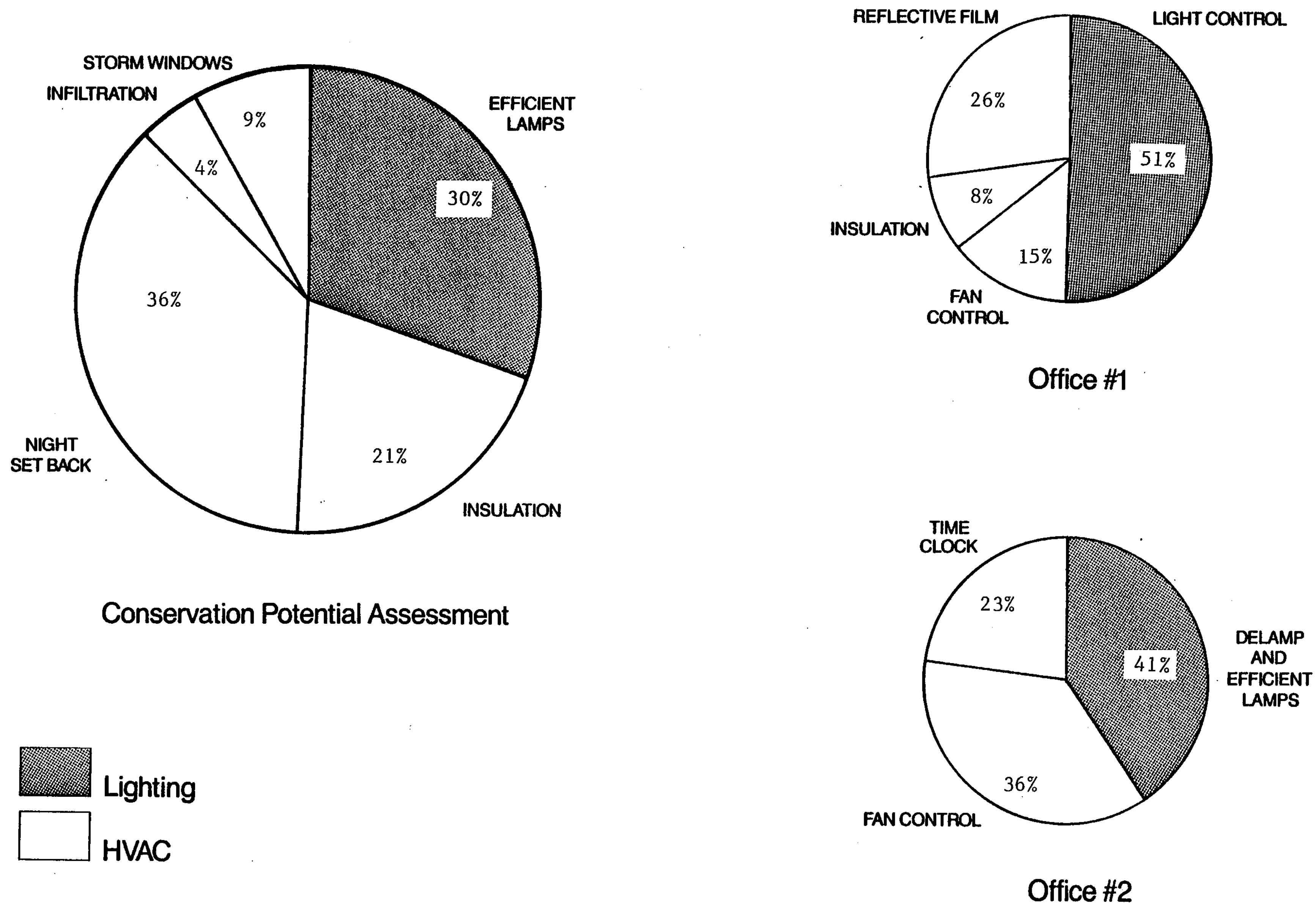


Figure 5.2

OFFICE BUILDING CONSERVATION

Simulated Electrical Savings



Level of Energy Savings. The differences in the baseline consumption levels and the end-use shares of the energy savings are reflected in the differences in the magnitude of conservation savings. Figure 5.3 compares the amount of savings expected from reductions in heating consumption for the CPA prototype with the savings estimated for CHEUS office #2 through simulation. In the CPA simulation, a 4-kwh/sq.ft. (13 kBtu) reduction was estimated for the heating load after the installation of conservation improvements. Predicted heating consumption dropped from 12 kwh/sq.ft. (41 kBtu) to 8 kwh/sq.ft. (26 kBtu). In CHEUS office #2, the simulated base heating consumption was 8 kwh/sq.ft (26 kBtu). After conservation, heating consumption was predicted to drop to 5 kwh/sq.ft. (17 kBtu). The smaller base for heating load lessens the conservation potential for heat savings.

The opposite pattern is noted in lighting energy savings in Figure 5.4. The magnitude of these savings is estimated to be 3-4 kwh/sq.ft. (10-14 kBtu) for both the CPA office and CHEUS office #2, but the base consumption for lighting was smaller in the CHEUS office #2. As a result, the percentage reduction in lighting load was greater in the CHEUS office #2 because of the smaller base load consumption.

Overall, the CPA estimated a reduction of 12 kwh/sq.ft. (43 kBtu) or 52 percent of total consumption for the installation of a package of measures estimated to cost $2.86/sq.ft. (1983 dollars). The estimates developed for the CHEUS office buildings were lower. The CHEUS estimates ranged between 6 and 9 kwh/sq.ft. (21-29 kBtu) energy savings, or a 30 to 40 percent reduction in total consumption. The CHEUS costs per square foot are also lower (1983 dollars)--$1.46 for office #1 and $.85 for office #2, as shown in Table 5.2.

Table 5.2

Office Building Conservation Simulated Results*

	CPA Prototype**	CHEUS #1	CHEUS #2
Savings			
kwh/sq.ft.	12.5	8.5	6.1
kBtu/sq.ft.	43	29	21
Percentage	52%	40%	31%
Cost/sq.ft.	$2.86	$1.46	$ .85
Simple payback	10 years	7 years	6 years

*Based on Typical Meteorological Year weather.
**1982 CPA, pages 4-5 and 4-8.

Updated Utility Estimates. In comparison with the CRMS, the CHEUS office buildings consume less energy per square foot and the estimated savings from conservation are greater. As Table 5.3 shows, more savings are expected in the lighting loads of the CHEUS buildings than the CRMS measures estimate for office buildings.

Table 5.3

CHEUS/CRMS Office Building Comparison

	Heat Pump		Resistance Heat	
Office	CHEUS #1*	CRMS	CHEUS #2*	CRMS
Base kwh/sq.ft.	21.2	20	21.4	26
Saving	8.5	3.2	6.1	3.6
Percentage	40%	16%	32%	14%
Savings/sq.ft.				
HVAC	4.2	1.1	4.2	2.3
Lights	4.3	1.8	1.9	.9
Other		.3		.3
Cost/sq.ft. (1983 $)	$1.46	$1.12	$ .85	$1.32

*Simulated results under Typical Meteorological Year weather.

Lesson Learned. While the CHEUS sample includes only two office buildings, some valuable insights about conservation potential in office buildings can be gained. Further research on more office buildings is necessary to determine how the following insights apply to the sector as a whole.

Figure 5.3

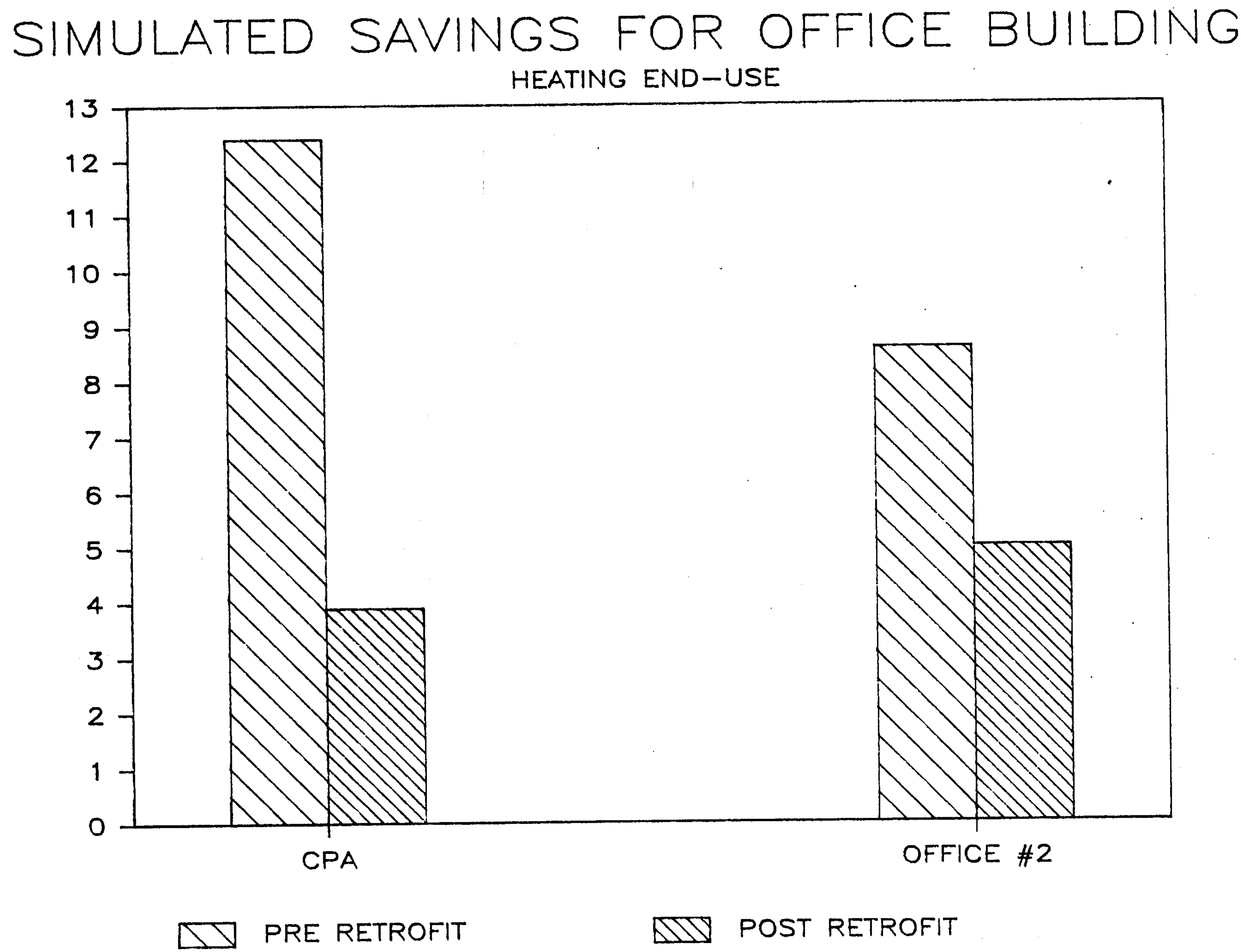
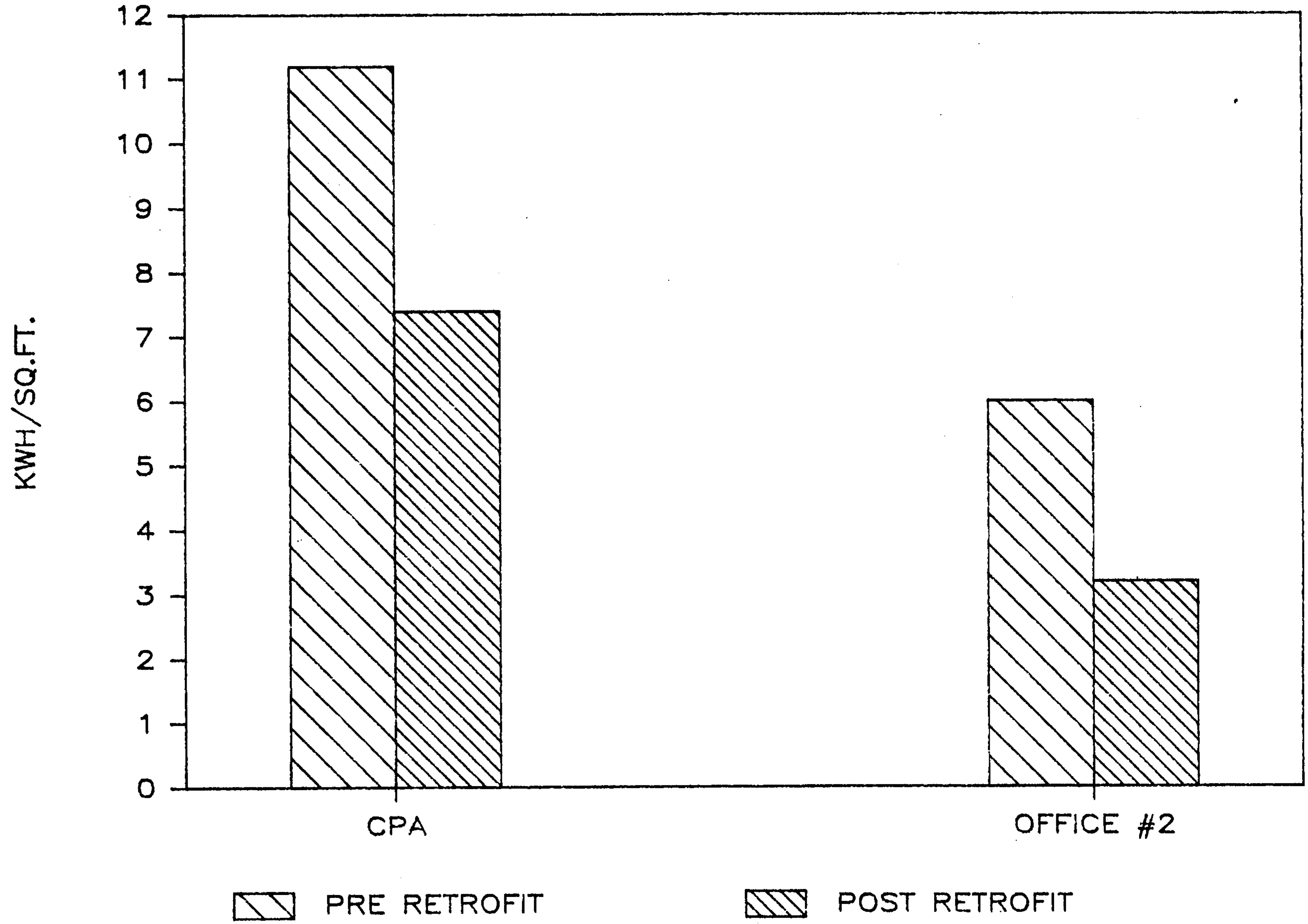

SIMULATED SAVINGS FOR OFFICE BUILDING
HEATING END-USE
KWH/SQ.FT.
13
12
11
10
9
8
7
6
5
4
3
2
1
0
CPA
OFFICE #2
PRE RETROFIT
POST RETROFIT

Figure 5.4

SIMULATED SAVINGS FOR OFFICE BUILDING

LIGHTING END-USE



1. Office buildings may consume less energy than was estimated in 1982, and heating may be a smaller share of the total load. Also, outlet consumption is likely to be a small but not an insignificant part of office building loads.

2. Recommended conservation measures are more likely to be HVAC and/or lighting control strategies and less likely to be shell improvements.

3. There may be less potential for energy savings in heating loads and more potential for energy savings in lighting loads.

5.4.3 Retail Stores

Building Descriptions. The first CHEUS retail store is an all-electric, 22,000-sq.ft. building. CHEUS retail #2 is a gas-heated, 37,000-sq.ft. hardware store. The CPA prototype for retail stores was a mixed office/retail building two stories tall with 6,000 sq.ft. Energy consumption and conservation estimates from this prototype were used for the retail sector.

Retail Building Consumption. The consumption estimates from the CPA from the 1983-84 data on the two CHEUS retail buildings are shown in Table 5.4.

Table 5.4

Retail Electrical Consumption
(kwh/sq.ft./year)
(Btu/sq.ft./year in thousands)

	HVAC	(%)	Lights	(%)	Other	(%)	Total
All electric							
CPA*	15.8		11.7		5.2		32.7
	53.9	(48)	39.9	(36)	17.7	(16)	111.5
CHEUS #1**	8.2		22.5		1.8		32.5
	27.9	(25)	76.7	(69)	6.1	(6)	110.7
Nonheat							
CPA*	.9		10.3		5.2		16.4
	3.1	(5)	35.1	(63)	17.7	(32)	55.9
CHEUS #2***	.1		15.3		1.7		17.1
	.3	(0)	52.2	(90)	5.8	(10)	58.3

*1982 CPA, pages 4-2 and 4-3.
**1984 hourly end-use data used due a major lighting retrofit in late 1984.
***1985 hourly end-use data.

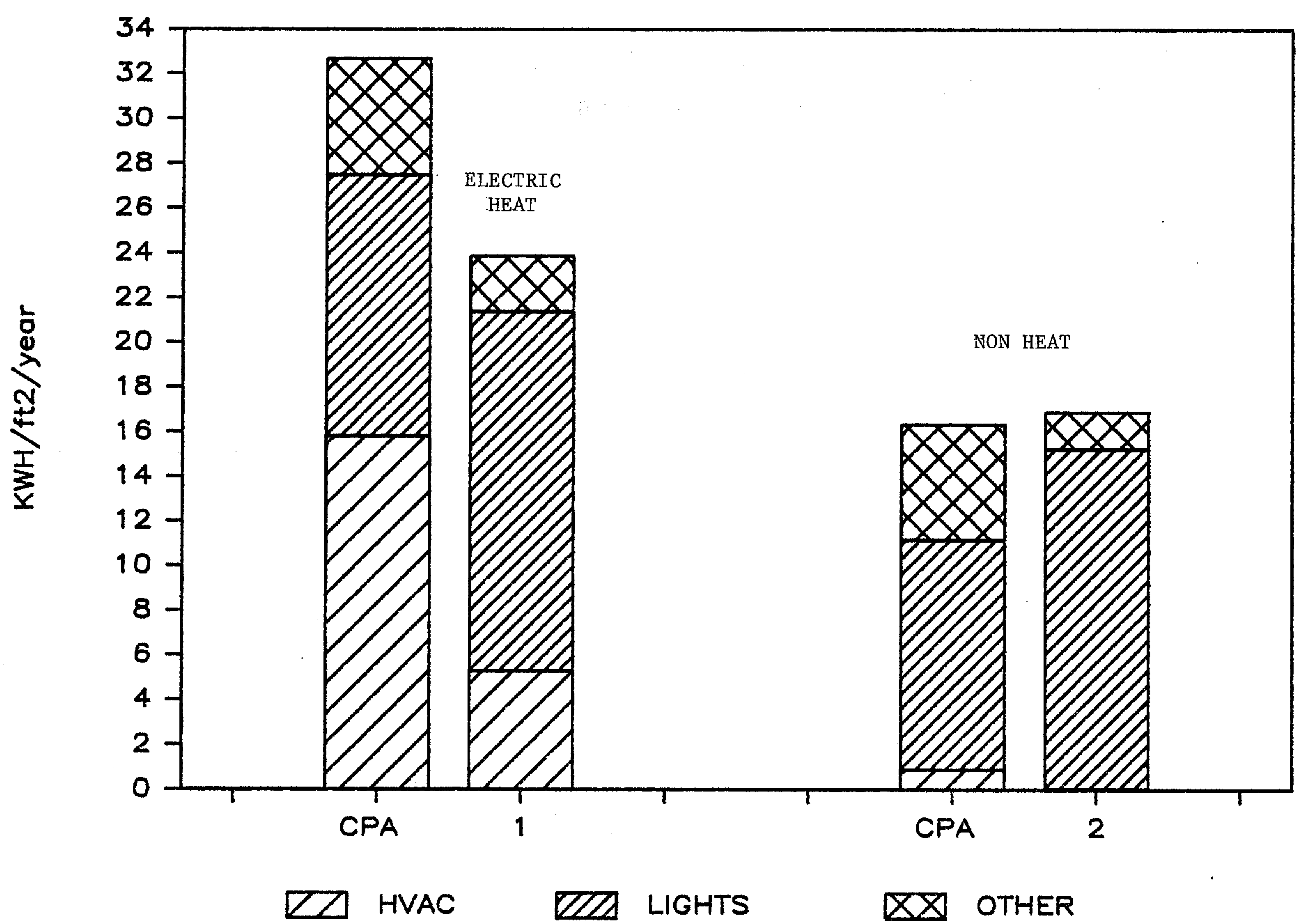
Interestingly, the total consumption is 32 kwh/sq.ft. (111 kBtu) for the CPA and CHEUS all-electric building estimates. The total consumption levels for the CPA and CHEUS gas-heated buildings are within 4.7 kwh/sq.ft. (2 kBtu). However, in both the electrically and gas-heated buildings the percentage share of the lighting end use is considerably larger in the CHEUS buildings than for the CPA estimates. This information is displayed in Figure 5.5.

Again, an accurate assessment of baseline consumption is important in determining conservation potential, as discussed below.

Conservation Measures for Retail Buildings. The CPA package of measures for retail buildings was comprised of the same measures as those listed for the CPA office building. Again, the set of measures were typical residential measures and served as proxies for commercial measures. Figure 5.6 indicates that 30 percent of the CPA retail energy savings were expected from lighting, while the remaining savings were from HVAC-related measures. The savings for the CHEUS retail show a different distribution. In the CHEUS retail #1, 50 percent of the total savings is expected from lighting retrofits. During the analysis, this particular building owner replaced the mercury vapor fixtures in the sales area with fluorescent tubes. While energy savings were a consideration, the primary reason for the change was the improved quality of the lighting on the merchandise. In the second CHEUS retail building, a nonelectric heat building, 90 percent of the electricity consumption was from lighting. As a result, all of the CHEUS retail electrical energy savings were from lighting conservation opportunities.

Figure 5.5

RETAIL BLDG. END USE CONSUMPTION



Level of Savings. Differences in baseline consumption and end-use shares affect the magnitude and nature of conservation savings in retail buildings. Figure 5.7 illustrates the differences between the estimated savings for heating, cooling, and lighting loads for the CPA prototype and the all-electric CHEUS retail #1. Due to the differences in the end-use shares for heating and lighting, greater savings from lighting conservation are expected in the CHEUS retail #1, and less is expected from heating load reductions. An increase in the cooling load is predicted in this CHEUS building, while the CPA prototype predicted no increase in cooling load. This is primarily due to the cooling requirements of the CHEUS retail #1; between May and October, cooling is 25 percent of total energy consumption for this particular building.

Overall, the CPA estimated a reduction of 12.7 kwh/sq.ft. (43 kBtu) or 51 percent of total consumption for installation of the package of measures estimated to cost $2.62/sq.ft. (1983 dollars). The savings estimates for the CHEUS retail buildings were lower. The CHEUS estimates ranged between 6 and 7 kwh/sq.ft. (19-25 kBtu) electricity savings, or 20 to 30 percent reduction in total consumption. The retrofit costs are also lower (1983 dollars): $.73/sq.ft. for the all-electric CHEUS retail building and $.19/sq.ft. for the electrical measures in the gas-heated CHEUS retail building, as shown in Table 5.5.

Table 5.5

Retail Building Conservation Simulated Results*

	CPA Prototype**	CHEUS #1***	CHEUS #2
Savings			
kwh/sq.ft.	12.7	5.7	7.3
kBtu/sq.ft.	43	19	25
Percentage	51%	20%	32%
Cost/sq.ft.	$2.62	$0.73	$0.19
Simple payback	8 years	4 years	3 years

*Based on Typical Meterological Year weather.
**1982 CPA, pages 4-5 and 4-8.
***Savings beyond owner-initiated 1984 lighting retrofit.

Updated Utility Estimates. Compared with the CRMS, the CHEUS retail buildings consume more energy per square foot and the estimated savings from conservation are greater. As Table 5.6 shows, more savings are expected in the lighting loads of the CHEUS retail buildings than the measures analyzed in CRMS estimate for retail buildings.

Figure 5.6

RETAIL STORE CONSERVATION

Simulated Electrical Savings

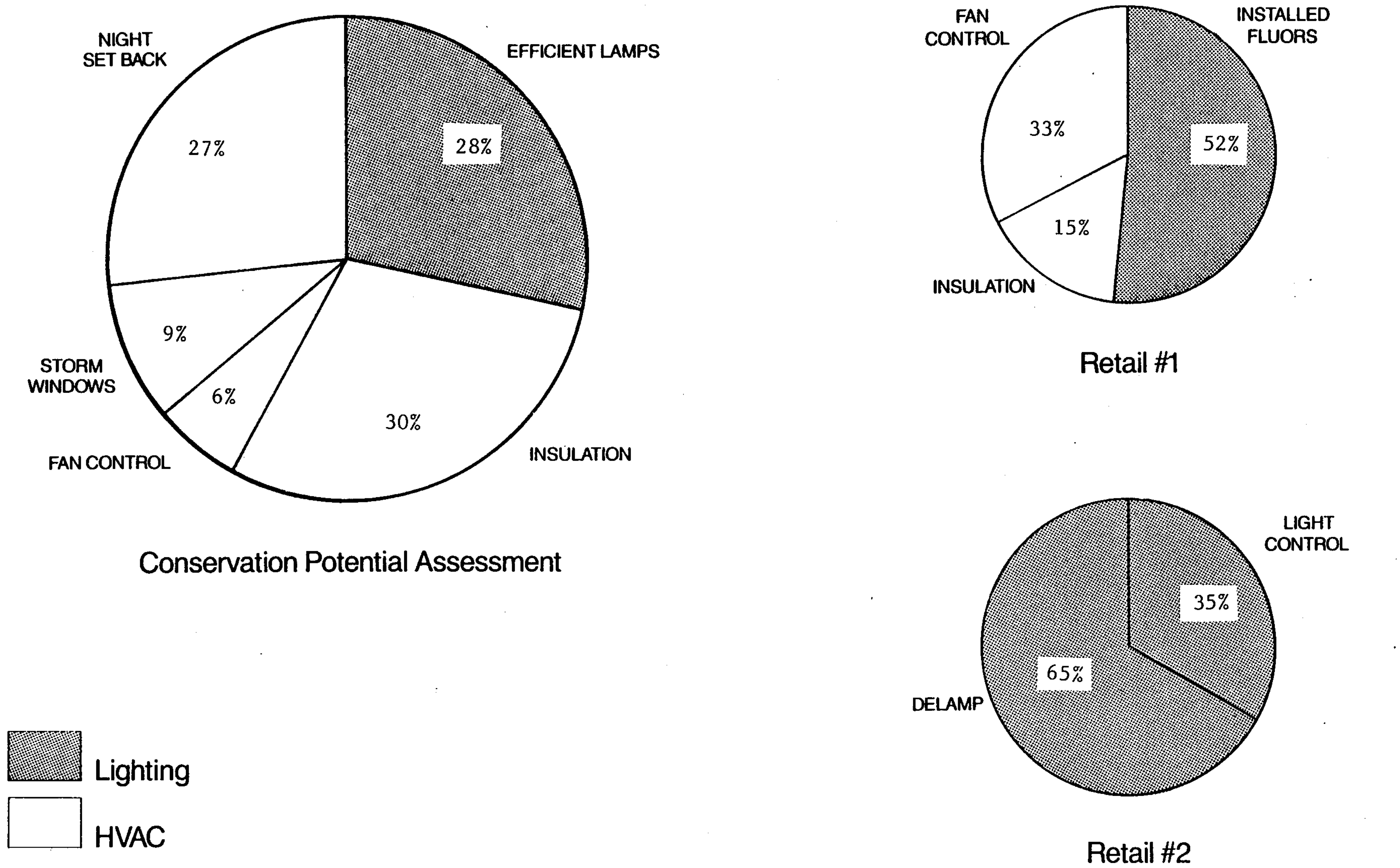


Figure 5.7

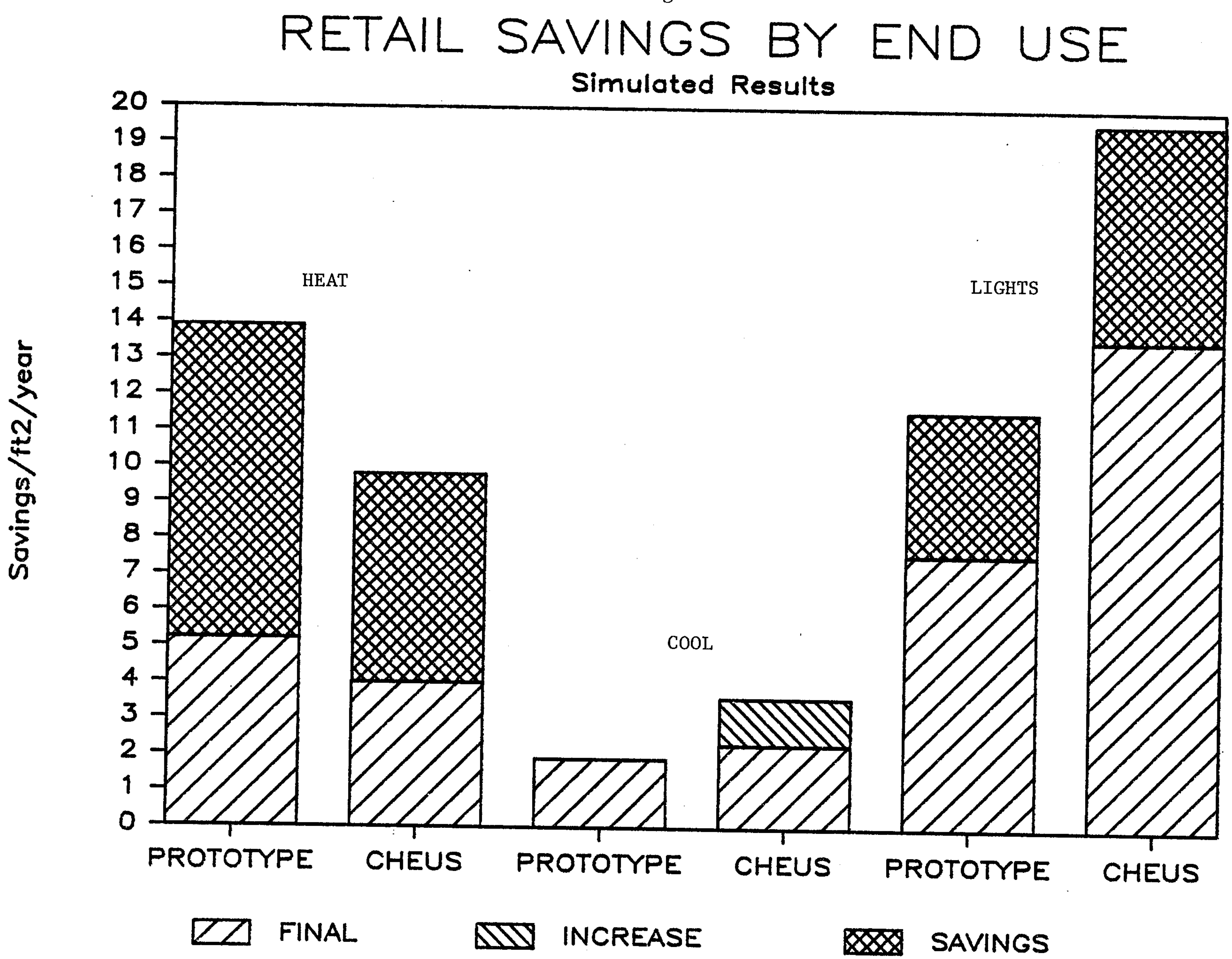

RETAIL SAVINGS BY END USE
Simulated Results
Savings/ft2/year
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
HEAT
COOL
LIGHTS
PROTOTYPE
CHEUS
PROTOTYPE
CHEUS
PROTOTYPE
CHEUS
FINAL
INCREASE
SAVINGS

Table 5.6

CHEUS/CRMS Retail Building Comparison

Retail	Resistance Heat		Gas Heat	
	CHEUS #1*	CRMS	CHEUS #2*	CRMS
Base kwh/sq.ft.	28.1	16	23	15
Savings	5.7**	1.7	7.3	2.2
Percentage	20%	10%	32%	15%
HVAC	5.7	1.1		
Lights		.5	7.3	2.1
Other		.1		.1
Cost/sq.ft. (1983 $)	.73	.56	.19	.82

*Simulated results based on Typical Meterological Year weather.
**Savings beyond owner-initiated 1984 lighting retrofit.

Lesson Learned. While the CHEUS sample includes only two retail buildings, some valuable insights about conservation potential in retail buildings can be gained:

1. Retail buildings may consume more energy for lighting than was estimated in 1982.

2. Conservation measures are more likely to be HVAC and/or lighting control strategies and less likely to be shell improvements.

3. The overall level of energy savings per square foot may be less than estimated by the CPA in 1982, but large savings with higher economic returns may be available.

5.4.4 Grocery Stores

Since a grocery store prototype was not developed for the CPA, no comparisons with the CPA are possible. However, a description of the conservation analysis is provided below for the two CHEUS grocery stores.

Building Descriptions. The first CHEUS grocery store is an all-electric, 25,000-sq.ft. building with an air-to-air heat pump system. CHEUS grocery #2 is a gas-heated, 17,000-sq.ft. store.

Grocery Building Consumption. The consumption estimates for these two buildings are shown in Table 5.7 and displayed in Figure 5.8.

Table 5.7

Grocery Electrical Consumption*
(kwh/sq.ft./year)
(Btu/sq.ft./year in thousands)

	Refrig.	(%)	Lights	(%)	HVAC	(%)	Other	(%)	Total
CHEUS #1	22.0		19.2		17.1		2.6		61.0
	75.0	(36)	65.5	(31)	58.3	(28)	8.8	(4)	208.2
CHEUS #2	53.1		25.5		0.7		4.6		83.9
	181.2	(63)	87.0	(30)	2.4	(1)	15.7	(6)	286.3

*1985 hourly end-use data.

A comparison of total building energy consumption shows that grocery #2, the smaller of the two buildings, has greater energy use per square foot. Considering total energy consumption (all fuels), grocery #2 consumes 55 percent more energy per square foot--324.1 kBtu/sq.ft./yr compared to 208.2 kBTU/sq.ft./yr for grocery #1. Two reasons account for the high energy intensity of the second store. First, the lighting levels are unusually bright, at 4.5 watts/sq.ft. compared to 3.4 watts/sq.ft. for grocery #1. Second, grocery #2 has more refrigerated cases than grocery #1, resulting in greater energy consumption per square foot. This increased number of refrigerated display cases reflects this store's policy of offering variety (including gourmet foods) to its customers.

Conservation Measures for Grocery Stores. The package of conservation measures for CHEUS grocery #1 includes installing strip curtains on the vertical refrigerator cases, rewiring the lights to allow for reduced lighting level during night stocking, retrofitting a heat recovery system on the compressors to heat the sales area, placing controls on the ventilation system, and insulating the ceiling. The major energy savings are expected from the heat recovery (32 percent of the total savings), the fan controls (27 percent), and lighting controls (25 percent). (See Figure 5.9.)

The package of measures for grocery #2 is quite similar. These include strip curtains, delamping, and rewiring the lighting switches for reduced levels during night stocking. In this gas-heated building, 80 percent of the electrical savings is expected to be obtained from the lighting measures (see Figure 5.9).

Level of Savings. Approximately a 15 percent reduction in total consumption is predicted in both buildings for the specified package of measures. The potential for savings is greater in grocery #2 due to the higher energy use. The conservation costs for grocery #1 are higher, at $1.70/sq.ft. (1983 dollars) due to the cost of the heat recovery system. The costs for grocery #2 are estimated at $.52 /sq.ft. (1983 dollars), as shown in Table 5.8.

Figure 5.8

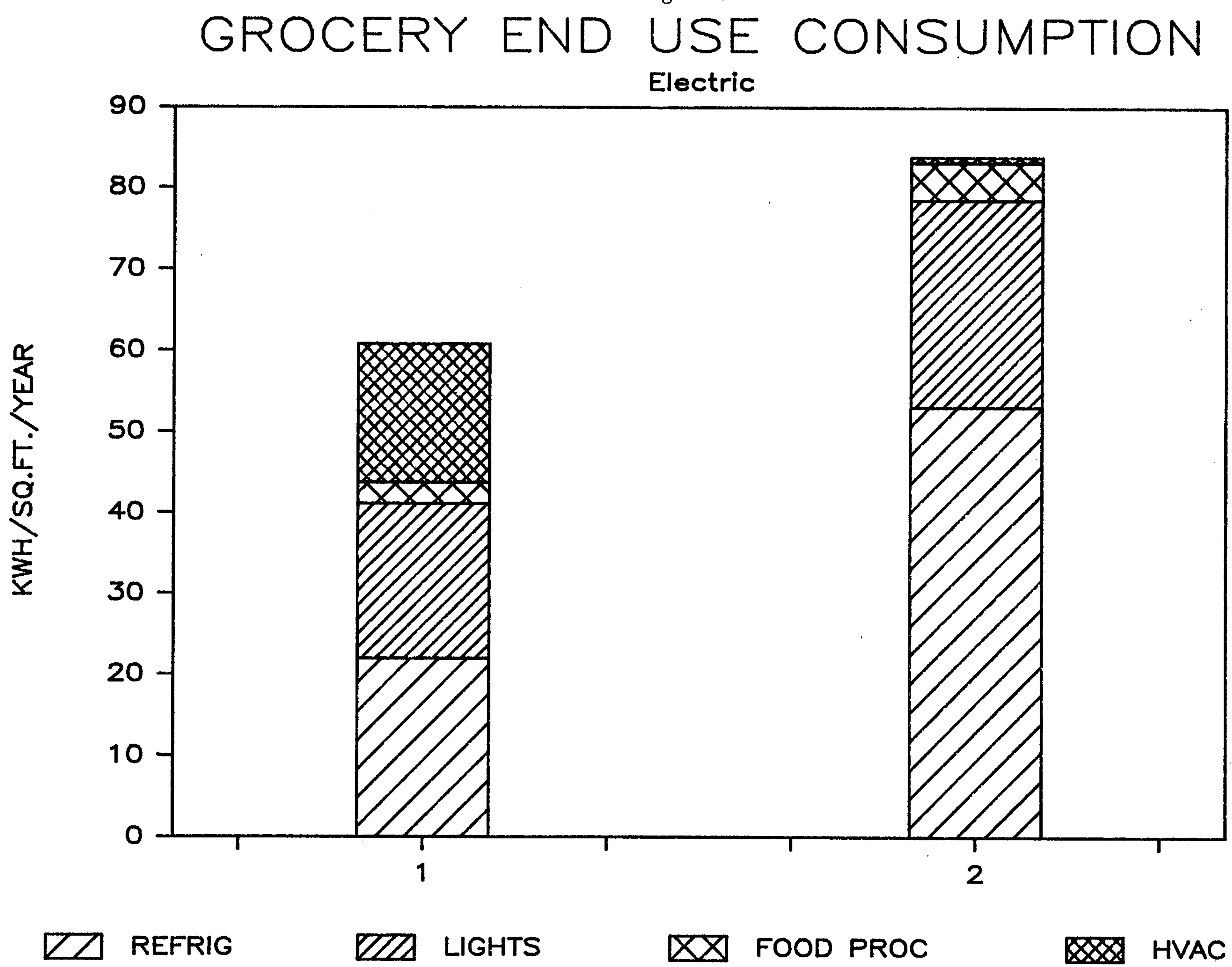

GROCERY END USE CONSUMPTION
Electric
KWH/SQ.FT./YEAR
0
10
20
30
40
50
60
70
80
90
1
2
REFRIG
LIGHTS
FOOD PROC
HVAC

Table 5.8

Grocery Store Conservation Simulated Results*

	CHEUS #1	CHEUS #2
Savings		
kwh/sq.ft.	9.1	15.2
kBtu/sq.ft.	31.5	51.9
Percentage	15%	17%
Cost/sq.ft.	$1.70	$ .52
Simple payback	6 years	4 years

*Based on Typical Meteorological Year weather.

Lessons Learned. Three interesting aspects of energy consumption and conservation emerged from this analysis of two grocery stores:

1. Refrigeration is the largest load with lighting being the second largest load. Together these loads account for approximately 70 to 90 percent of annual consumption.
2. HVAC and lighting controls, including delamping, are the primary conservation measures common to both buildings. These measures also constitute over 50 percent of the energy savings.
3. The level of energy savings is directly proportional to the energy consumption. More savings are expected from the building with greater energy consumption.

5.4.5 Restaurants

Again, no comparisons with the CPA are possible for restaurants, since restaurant prototypes were not created for the CPA. The following sections describe the conservation analysis for the two CHEUS restaurants.

Building Descriptions. The first CHEUS restaurant is a fast-food restaurant with inside dining and a drive-up service window. The second restaurant is a typical "coffee shop" restaurant open 24 hours a day, seven days a week. Both restaurants use natural gas for cooking and heating. Only restaurant #2 uses gas for water heating.

Restaurant Energy Consumption. The consumption estimates for these two buildings are shown in Table 5.9 for electrical energy and total building energy. Figure 5.10 shows that two-thirds of the energy usage for restaurant #1 is electricity compared to a one-third electrical consumption level for restaurant #2. The difference is primarily due to a greater use of gas equipment (grills) in restaurant #2.

Figure 5.9

GROCERY STORE CONSERVATION

Simulated Electrical Savings

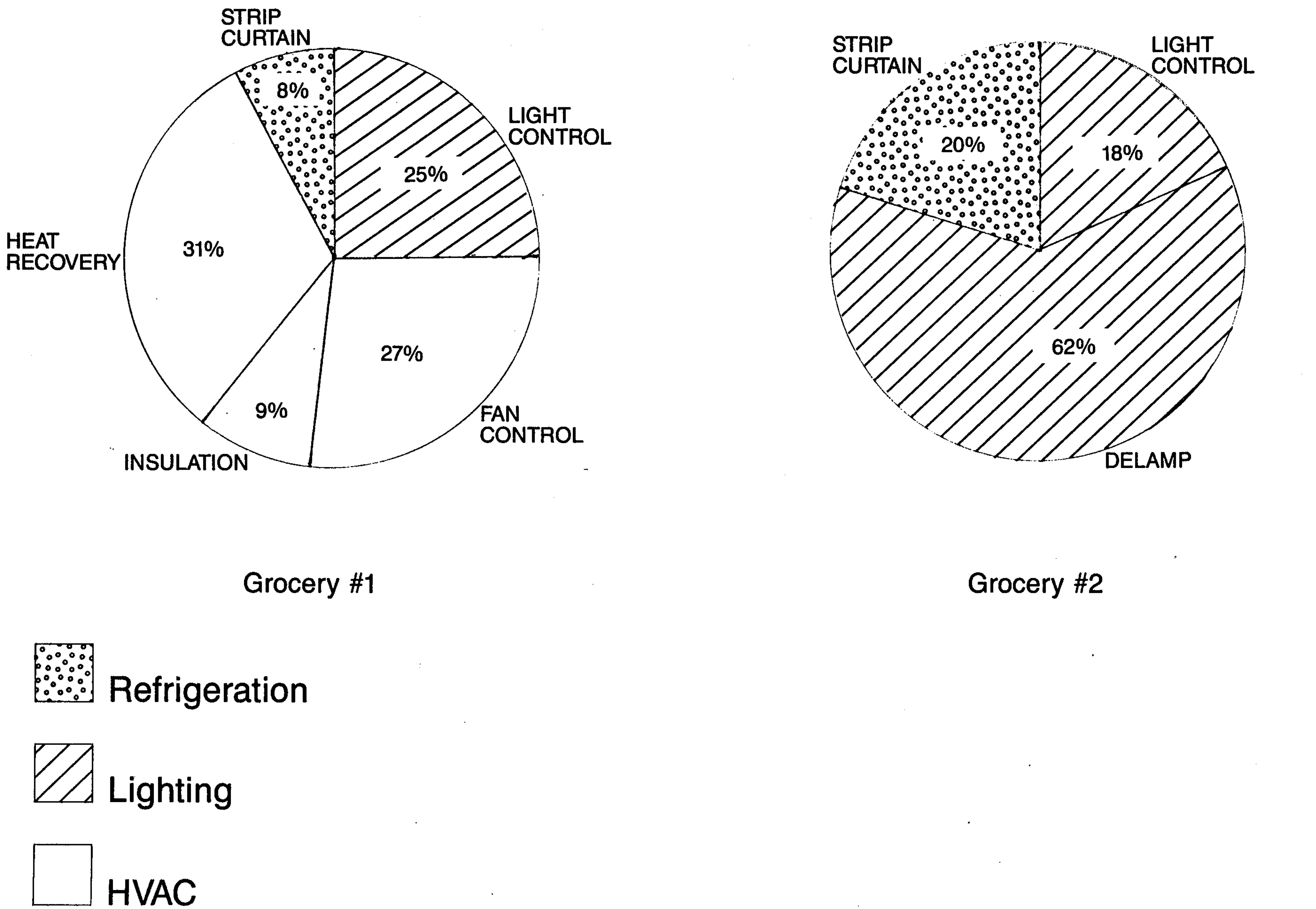


Figure 5.10

RESTAURANT END USE CONSUMPTION

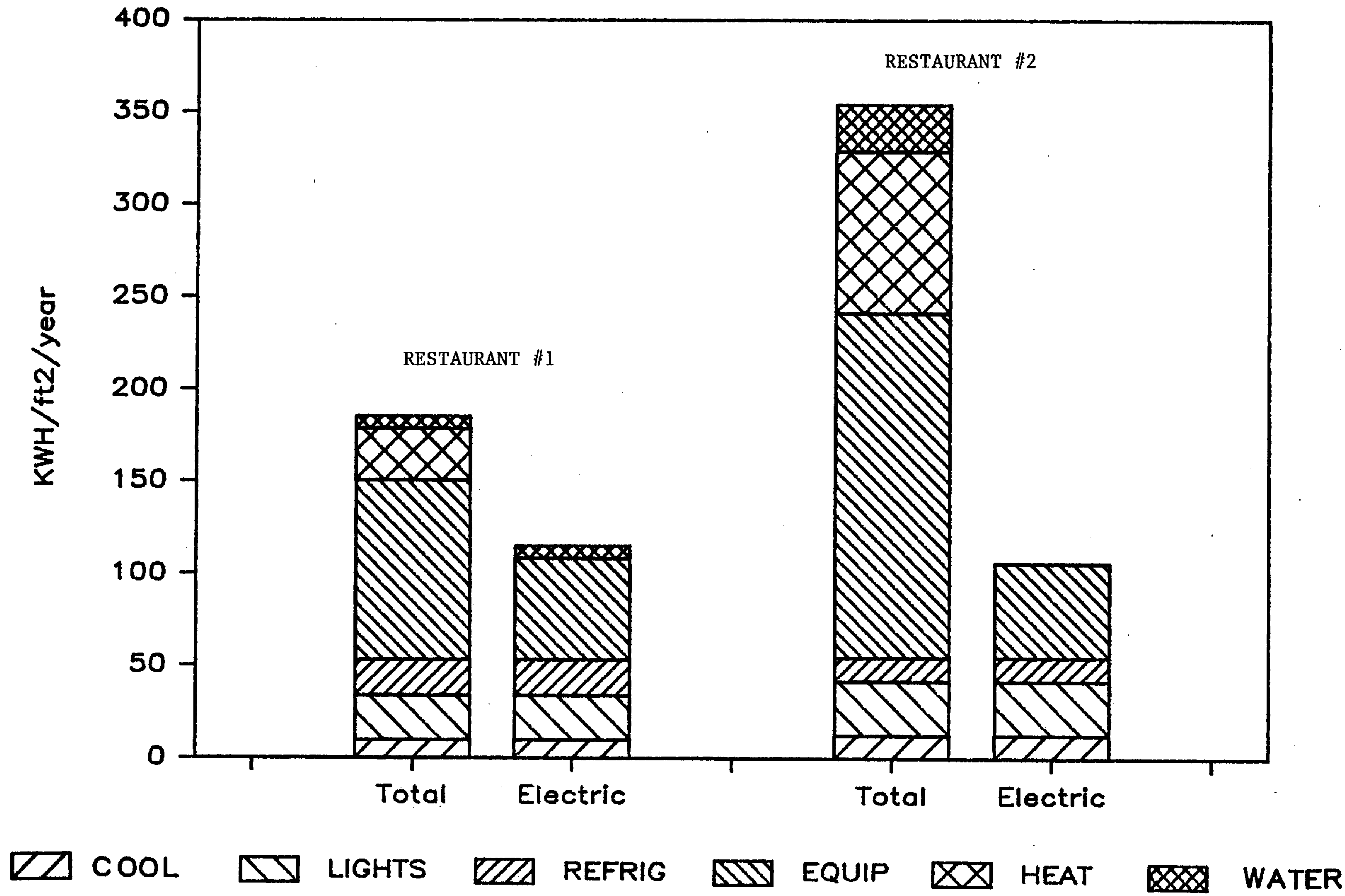


Table 5.9

Restaurant Energy Consumption Per Square Foot

	Equipment	HVAC	Lights	Refrigerator	Hot Water	Total
CHEUS #1						
Electric*						
kwh	55.1	10.0	24.0	19.4	7.0	115.5
kBtu	187.9	34.1	81.8	66.2	23.9	394.2
percentage	48	8	21	17	6	100
All Fuels**						
kwh	97.8	37.8	24.0	19.4	7.0	186.0
kBtu	333.8	129.0	81.8	66.2	23.9	634.7
percentage	53	20	13	10	4	100
CHEUS #2						
Electric*						
kwh	51.4	12.6	29.2	12.8	0	106.0
kBtu	175.3	43.0	99.6	43.7	0	361.6
percentage	49	12	27	12	0	100
All Fuels**						
kwh	200.5	98.8	29.2	12.8	24.9	366.2
kBtu	684.3	337.2	99.6	43.7	85.0	1,249.8
percentage	55	27	8	3	7	100

*1985 hourly end-use data.
**1985 hourly end-use data plus simulated natural gas end-use shares constrained by monthly total fuel consumption.

Conservation Measures. The conservation measures for CHEUS restaurant #1 include installing controls on the exterior lights and signs, and controls on the grill exhaust and makeup air fans in the kitchen. Conservation opportunities for the restaurant providing 24-hour service are limited. The measures include replacing the mercury vapor outside lights with high-pressure sodium fixtures and installing strip curtains on the freezer doorway. In both buildings, 80 percent of the electricity savings is expected from the exterior lighting strategies (see Figure 5.11).

Level of Savings. The expected level of savings is the same for the two restaurants, 6 kwh/sq.ft. (20 kBtu), or around 5 percent of total electrical consumption. The costs for the measures were higher for restaurant #2, as shown in Table 5.10, because of the greater expense for the lighting fixture replacement. Conservation costs were estimated at $1.78/sq.ft. for CHEUS restaurant #2, compared to $.54/sq.ft. for restaurant #1 (1983 dollars).

Figure 5.11

RESTAURANT CONSERVATION
Simulated Electrical Savings

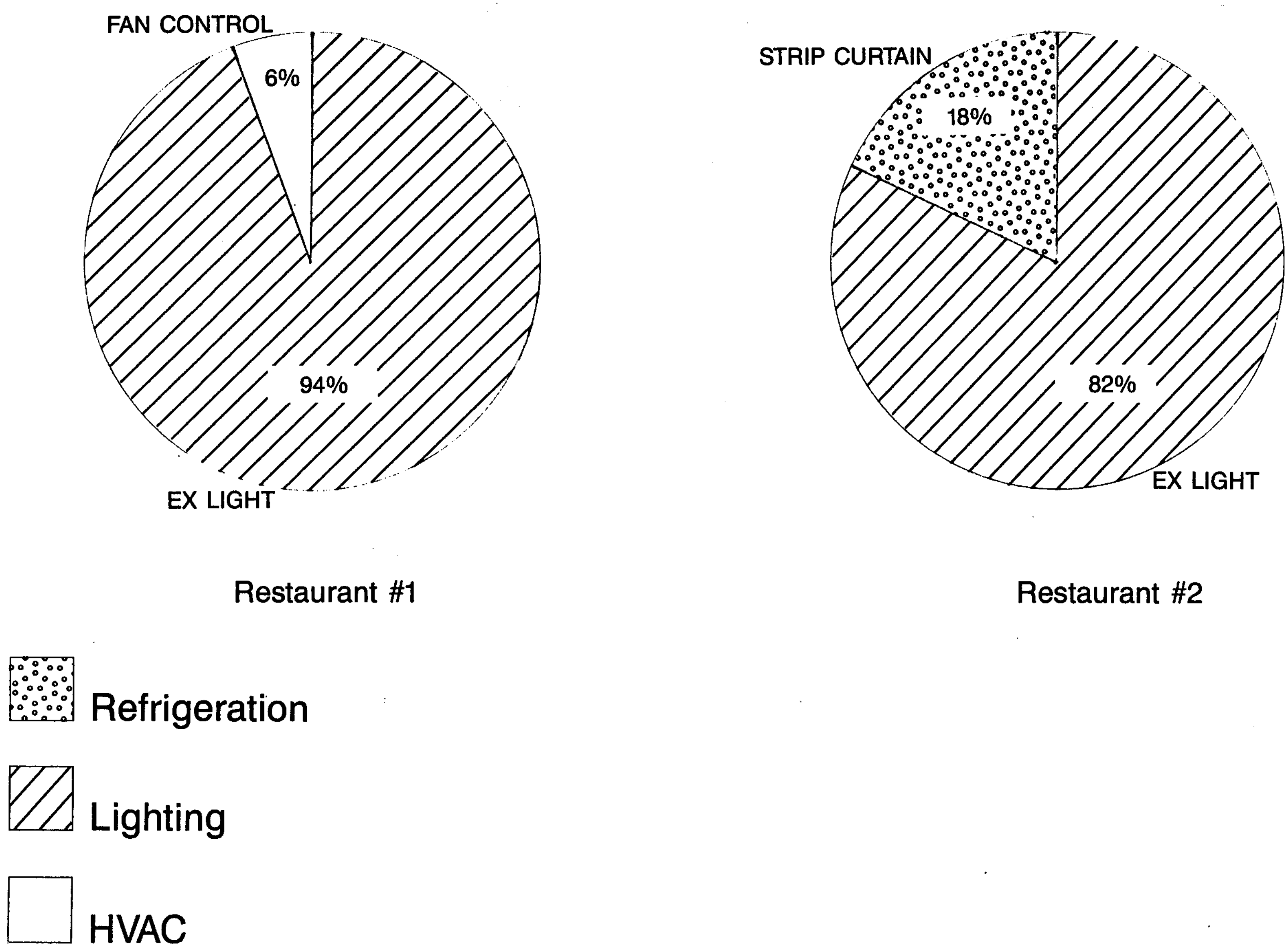


Table 5.10

Restaurant Conservation Simulated Results*

	CHEUS #1	CHEUS #2
Savings		
kwh/sq.ft.	6.4	6.0
kBtu/sq.ft.	21.8	20.5
Percentage	6%	5%
Cost/sq.ft.	$0.54	$1.78
Simple payback	3 years	10 years

*Based on Typical Meteorological Year weather.

Lessons Learned. Two interesting aspects of energy consumption and conservation emerged from this analysis of two restaurants.

1. Food preparation equipment accounts for 50 percent of both the electrical and the total building consumption in both of the two CHEUS restaurants.

2. Conservation opportunities are limited for electrical energy savings. Outdoor lighting strategies achieve the greatest amount of energy savings.

5.4.6 Conservation Supply Curves

Conservation potential can be expressed in terms of the dollars needed to save energy. By estimating the cost of conserved energy and cumulatively adding the estimated energy savings of a package of conservation measures, a supply curve of conserved energy can be developed. As such, a supply curve shows the energy available through conservation, expressed in cost per unit of energy.

To develop a supply curve, the measures are ranked in order of increasing cost. The vertical coordinate (y-value) of each measure is the cost of the energy saved, expressed as mills per kilowatt saved. The horizontal coordinate (x-value) is the cumulative energy saved by that measure and all measures preceding it in the supply curve.

The information gathered from the CHEUS conservation analysis can provide the "beginnings" of a supply curve for the four different types of study buildings. Of course, more data from the analysis of additional buildings and conservation measures are needed to build a reliable conservation supply curve. Nonetheless, characterizing the conservation analysis with this technique brings an interesting perspective to the available data.

The results of the average cumulative costs and savings for the electrical energy conservation measures found by CHEUS to be cost effective to City Light are displayed in Figure 5.11. The pattern of higher costs for each additional kilowatt-hour saved emerges for all four building types. For example, in the CHEUS office buildings the cost of the most cost-effective measure (garage lighting controls) is 5.2 mills/kwh/sq.ft. The second measure, fan controls, provided for .2 kwh/sq.ft./yr for an average cost of 5.7 mills/sq.ft. for the two measures.

The results in Figure 5.12 show that the magnitude of the savings is not directly related to the intensity of the electrical energy use of the building type. While restaurants have three and four times the electrical consumption per square foot of the retail and office buildings, the combined measures for the CHEUS restaurants, offices, and retail stores totaled around 12 to 14 kwh/year. This was possibly due to the limited electrical conservation opportunities in the CHEUS restaurants.

Given this same level of energy savings, a difference in the cost of conserved energy is apparent. The cost of electrical energy savings was the lowest for the CHEUS retail stores and the highest for the CHEUS restaurants, with CHEUS office building measures in the middle. The grocery store measures had notably high levels of estimated savings for relatively low costs. This was possibly due to the inexpensive delamping and lighting control conservation opportunities in the CHEUS grocery stores.

As more information becomes available, these supply curves will become a useful tool in the analysis of conservation potential for resource strategy planning and conservation program development.

5.4.7 Impact of the Marginal Value of Energy

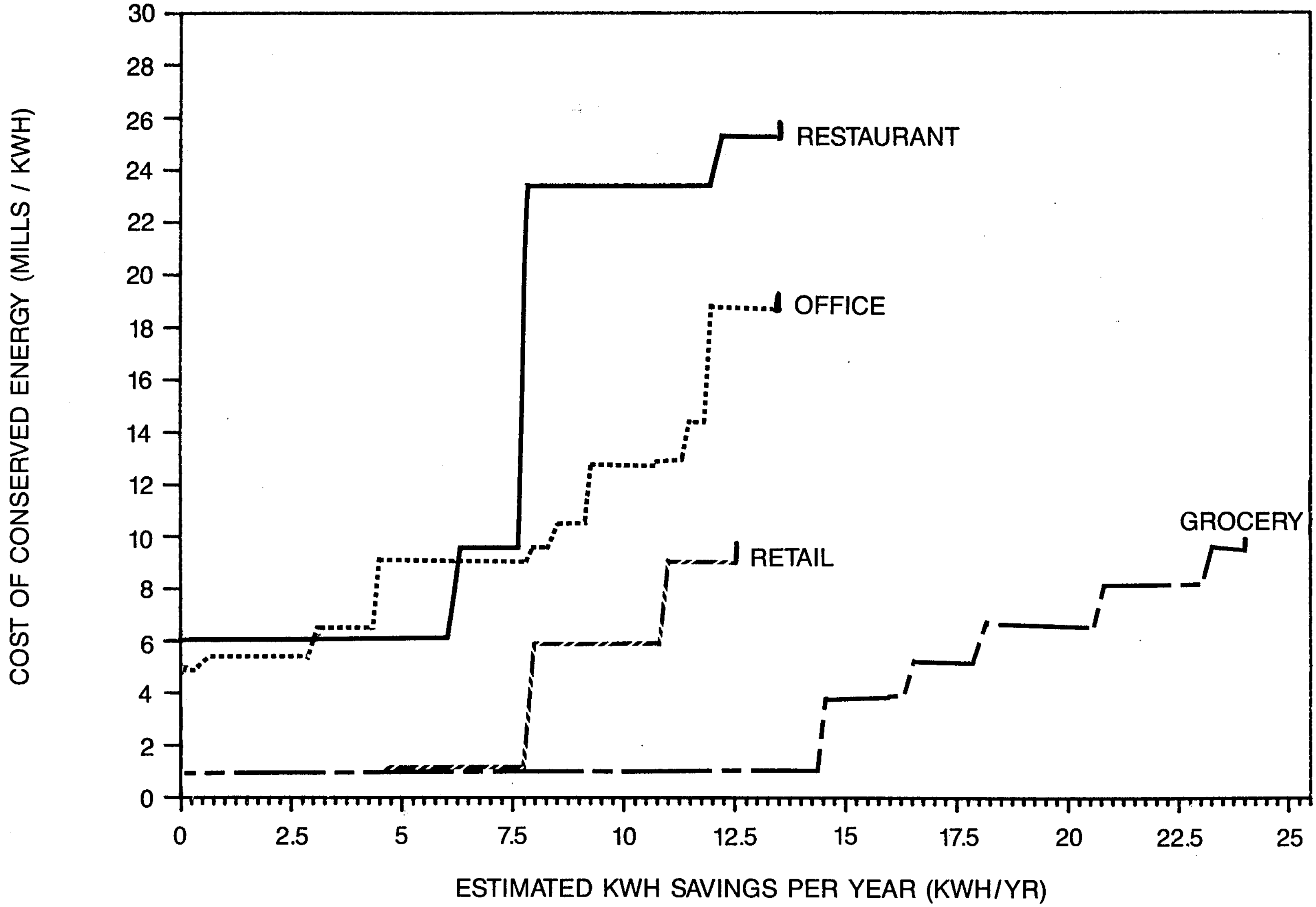
City Light computes the benefits from conservation savings as the value of energy saved from the conservation measures. The value of these energy savings is set at the marginal cost of supplying energy. City Light uses two planning values for the marginal cost of energy. The first one is set at the estimated incremental cost to the region of new fossil fuel generating facilities. The cost to the region of this resource combination of gas turbines and a coal plant is termed marginal thermal value (MTV). The MTV projections are documented in the City Light Energy Resources Data Base 1983.

The second marginal value of energy is based on using a combination of gas turbines and the energy rates levied by BPA to supply energy. The marginal value of energy to City Light (MVCL) represents the utility perspective and the marginal thermal values represent the regional perspective.

Figure 5.12

SUPPLY CURVE OF CONSERVED ELECTRICITY

ESTIMATED SAVINGS FOR 25 YEARS



In resource planning, the higher marginal thermal value is used by City Light because: (1) the BPA rates do not reflect the costs to the region of additional electrical generation resources; (2) there is a presumption that the total energy consumption of the region will exceed the capacity of the region's current resources within the time horizon (20 years) of City Light's strategic planning, requiring the acquisition of additional generation or conservation resources; and (3) City Light's planning efforts are designed to support long-term strategy analysis, rather than short-term maneuvers and tactics.

However, it is interesting to note the impact on the number of conservation strategies recommended using the two different perspectives of the marginal value of energy. The measures analyzed in Chapter 5, Section 3, are those estimated to be cost effective under the MTV of energy. However, each package was examined for differences using the marginal value to City Light. In five of the eight CHEUS buildings, there would be no change in the measures selected under the two sets of marginal cost. For two of the buildings, one additional measure was added under the higher value of energy (MTV) to the package developed using the marginal value to City Light. Only in the large office building did the package change considerably under the two values of energy; using the marginal cost to City Light, only two measures would be recommended, compared to a total of six measures identified using the MTV of energy.

Appendix B provides a full listing of all measures considered for each CHEUS building, along with the MVCL and MTV ranking of the measures.

5.5. Conclusion

The preliminary findings on the end-use consumption and conservation potential of the eight buildings in the CHEUS reveal a number of differences about commercial building energy usage and savings from estimates developed by City Light before this project began. While a more thorough understanding is needed of how well these eight buildings represent the commercial sector, valuable insights on energy consumption and conservation can be gathered from these case studies. The following conclusions summarize the increased level of knowledge obtained from the end-use research and conservation analysis on these eight commercial buildings:

1. The consumption levels per square foot and the end-use shares of consumption may be different than were estimated in 1982. Office buildings may consume less energy in total consumption, and heating may be a smaller share of the total load. In retail stores lighting may be a greater share of total consumption.

2. The predominant opportunity for conservation in all building types is installing controls on the HVAC and lighting systems rather

than making shell improvements. Commercial buildings are not big residential structures but have an entirely different set of cost-effective conservation strategies. In planning future conservation programs, City Light could expect modifications in HVAC and lighting systems in existing commercial buildings.

3. Based solely on the cost and savings estimates of electrical conservation opportunities, the level of energy savings for each dollar of investment varied, as expected, across building types. Generally, on a savings-per-square-foot basis, the two study grocery stores had the greatest number of kilowatt savings and the two study restaurants had the least amount for a given level of conservation investment.

Further analysis on the composition of the commercial sector is needed before these valuable insights from eight case studies can be applied to the sector as a whole.

Chapter 6

INSTALLATION OF RETROFITS

6.1. Purpose

The purpose of installing the conservation measures was to assess the impact of measures on the hourly end-use loads. This provided a unique opportunity to measure by end use by hour the true load reductions due to the conservation measures. It also provided the opportunity to compare the predicted, simulated loads by end use with actual loads, and thus to validate the simulation model for the buildings.

This section describes the overall process used to install the selected conservation measures. A full report on the experience and lessons learned is available: The Installation of Energy Conservation Measures in Commercial Buildings.

6.2 Solicitation of Participation

The first step in the installation process involved obtaining a participation agreement from each building owner/representative. An engineering consultant, Seton, Johnson, and Odell, was hired to develop a marketing approach, present the project to the building owners, develop a plan and a schedule for the retrofits, and obtain a signed owner agreement form. Figure 6.1 displays the steps taken with each building by the consultant in conjunction with City Light staff. Appendix C contains the participation agreement form.

Seven of the eight CHEUS building owners initially agreed to participate. Building owners were approached in August 1985, and by October 1985 owner agreements had been signed. One grocery store, grocery #1, declined to participate due to the subsequent sale of its chain of stores in the Northwest. This store will eventually be remodeled into retail shops.

6.3 Installation Management

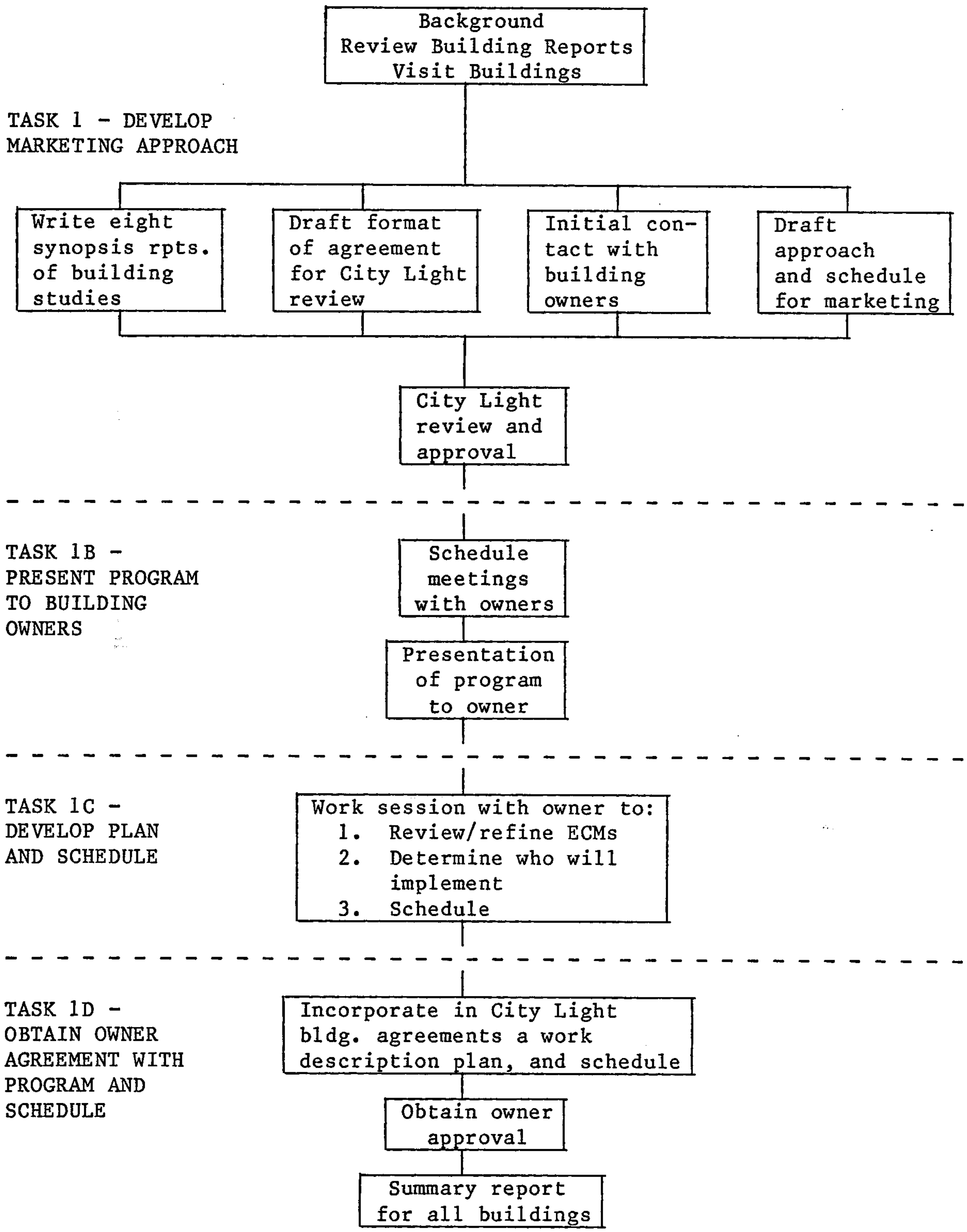
To ensure a timely completion of the retrofits, the consultant, together with City Light staff, provided assistance to the participating owners/representatives in preparing bid specifications, reviewing contract bids, selecting the contractors, and tracking progress. All installations were field-verified including photo documentation before, during, and after installation, where possible.

Bid specification development began in September and continued through November 1985. By mid-December 1985, all contractors had been selected. The retrofit installations began in December 1985 and were completed in June 1986.

INSTALLATION OF RETROFITS

FIGURE 6.1 - WORK FLOW: OBJECTIVE 1

AGREEMENT AND SCHEDULE



6.4 Role of City Light Staff

Due to staff resource and time constraints, a consultant was hired to approach building owners/representatives and provide assistance for the installations. However, City Light staff took an active role in all phases of the installation process. City Light commercial auditors participated in the development of the bid specifications, provided assistance to building owners/representatives, and verified the installations. This work provided a unique opportunity for the staff to gather practical experience in a commercial building retrofit project, an experience that went beyond their usual role of conducting audits and providing recommendations. The lessons learned from these installation experiences have already played an important role in the development of procedures for the Commercial Incentive Pilot Program for City Light customers.

6.5 Financing

The installation of the conservation measures was primarily financed with a BPA grant. As part of the participation agreements, owners/representatives agreed to pay 10 percent of the actual costs while the remaining 90 percent--up to a maximum amount--would be reimbursed through City Light as part of the BPA grant award. The actual cost for the retrofits for the seven participating buildings was $192,117.

Chapter 7

FUTURE ANALYSIS

7.1. Analysis Applications

The CHEUS provides a unique opportunity to build an understanding of commercial buildings in the City Light service area. The project provides empirical measurements of hourly end-use electrical consumption and building and occupant characteristics for a small number of buildings. Chapters 4 and 5 of this report provide a preliminary analysis of the electrical consumption and conservation potential of these buildings. The purpose of the analysis agenda is to build upon this early work and to propose a general plan for the upcoming analysis. It is anticipated that this agenda will be modified as specific tasks are undertaken and as additional data from utility and regional research studies become available to expand the data collected under the CHEUS project.

The applications of the proposed analysis will be widespread throughout City Light. This information will be used by Conservation Planning for program design and conservation supply curve modeling. Load Forecasting can use these data in the building stock model, the annual forecast, and peak forecast. This information will be valuable to Rates Design in cost of service and rate impact studies. Operations will be able to use the information for daily estimation of expected 24-hour load shapes and "cold" day/week contingency plans. The data can also serve as input for diversity modeling performed by System Engineering for sizing system requirements. Environmental Affairs can use the information to assess the impact of load growth due to new commercial construction for the purposes of State Environmental Protection Act (SEPA) requirements.

7.2 Individual Building Analysis

7.2.1 Characterizing Energy Use

The focus of this analysis is to develop the hourly end-use distribution of electrical consumption for the eight commercial buildings. Chapter 4 provides the preliminary answers to fundamental questions about building level consumption. Additional questions about consumption changes over the different time periods (annual, seasonal, monthly, daily, hourly) still remain. These include:

- o What are the end-use load shapes?

- o How do the load shapes vary over time? In particular, how sensitive is consumption to outside temperatures? Which end uses are weather sensitive?

- o What are the contributions made by each end use to peak electric use?

- What are the determinants of energy consumption (structural characteristics, activity levels, hours of operation, weather)?

- What are the interactions of the end uses?

7.2.2 Assess Conservation Potential

The conservation assessment of a building is the analysis of potential energy savings from the implementation of conservation measures. Using a computer simulation model for thermal performance, the CPA of the eight CHEUS buildings has been completed and the results are presented in Chapter 5.

To broaden the findings from the CHEUS buildings, conservation analysis is currently planned for an additional six buildings representing different building types than the original eight selected. These include a warehouse, a bank, a service station, a school, a motel, and a new office building. This work, expected to be completed in 1986, will enhance City Light's understanding of cost-effective measures and their estimated levels of savings and costs.

In addition to the conservation potential of individual buildings, the conservation analysis of CHEUS buildings can contribute to an understanding of the value of computer simulation models. Because the CHEUS buildings are monitored at the hourly end-use level, a number of research topics regarding the differences between measured and simulated energy consumption can be addressed. These include:

- What simulation inputs have the largest impact on predicting end-use loads (HVAC, schedules, weather)?

- How many data are needed to estimate building schedules (six weeks to 12 months)? What is the level of accuracy gained for each additional increment of data?

- How accurately does the simulation model predict building loads for various time scales (hourly, cold day, string of cold days, monthly)?

- Are heating and cooling loads consistently over- and/or underestimated by the simulations?

- What are the limitations of using simple and complex computer simulation models for predicting end-use load consumption?

7.2.3 Analyze Post-Retrofit Load Reductions

The installation of the identified cost-effective conservation measures in seven of the eight monitored CHEUS buildings provides a unique opportunity to evaluate carefully the conservation savings for each end-use load at the hourly level. Over the next two years (1986-87), a number of questions can be addressed regarding the impact of the retrofits. These include:

- Which measures save energy?
- What is the impact of the measures on the end-use load shapes, the contributions to peak electric use, and the potential for conservation?
- Do these measures save as much energy as predicted?
- Which measures are cost effective? What is the relation of cost to energy saved?
- What is the relation of savings to intensity of consumption?
- What are the interactions among the end uses? In particular, what is the net energy reduction from lighting reductions? Does the balance point (the point when heating changes to cooling mode) of the building change when lighting is reduced? Do the occupants change their behavior in response to reduced lighting, such as install desk lighting in delamped office areas?
- Do operation and maintenance efforts impact savings?
- Is there a method that can predict what electrical consumption would have been in the absence of the retrofit?
- How do the measures change load profiles?

7.3 Building Sector Analysis

While the focus of the CHEUS is the comprehensive study of eight commercial buildings, the findings from this research can be expanded as information from similar studies becomes available. The BPA and City Light are both conducting intensive research studies of commercial buildings in the City Light service area.

7.3.1 End-Use Load and Conservation Assessment Program (ELCAP)

The Commercial Base Study of the ELCAP effort sponsored by BPA provides an unprecedented opportunity to examine commercial building energy usage based upon empirical measurements of building characteristics, energy use determinants, and hourly end-use electrical consumption. At present, arrangements have been made to survey and instrument approximately 150 randomly selected commercial sites in the Seattle metropolitan area.

The study has been configured to provide a consistent set of hourly end-use data for a large sample of commercial buildings stratified by primary building use. Within the 10 building use categories, sites were randomly selected with respect to age (post- or pre-1980 construction) and size (small, larger, or very large). As such, the sample should provide a reasonable basis to study the variations of building energy use within and among commercial building types.

Installation of the monitoring equipment began in mid-1985 and is expected to be completed in early 1987. Data will be available after it has been verified and data access procedures are developed. Access to these data is coordinated through the ELCAP users committee. Questions for ELCAP data analysis include characterizing energy consumption not only at the building level, but also answering these questions at the sector level due to the nature of the large, random sample. These include:

- What are the end-use load shapes by building type? What is the distribution of the end-use consumption over time?
- When is peak and what is its duration? Which end uses contribute to peak consumption periods?
- What is the potential for load management and energy conservation for the major electrical end uses?

7.3.2 Public Utilities Regulatory Policy Act (PURPA) Data

As required by PURPA, City Light instrumented over 200 randomly selected commercial customer meters with monitoring equipment to obtain hourly measurements of total load during 1983. While PURPA requirements no longer apply, monitoring of these meters continues as the data are valuable for cost of service studies. City Light's Rates and Consumer Research Unit is preparing approximately 1.5 years of data for analysis. These hourly load profiles, coupled with end-use load shapes derived from CHEUS and ELCAP data, provide City Light with an opportunity to extrapolate load shape analysis to the building sector level.

Questions include:

- Do typical load profiles emerge by type of commercial activity?
- What is the variability in total load across the different patterns over time? Can end-use patterns explain the variance observed?

- Do the determinants of energy consumption identified with CHEUS and ELCAP data hold for this PURPA sample of customers?

7.3.3 Pacific Northwest Nonresidential Building Survey

The BPA intends to conduct a survey of nonresidential buildings in the Pacific Northwest. The purpose of the survey is to create a base of characteristics information for a large random sample of nonresidential buildings in the region. In addition to energy consumption, characteristics include floor area, fuel types, equipment characteristics, schedules of operation, economic indices, and architectural characteristics. Applications of the data include long-term load forecasting, conservation assessment, and conservation program design.

The survey will be administered in three stages, with the number of buildings surveyed decreasing as the intensity of the survey increases. The first stage survey of 14,000 buildings in the region provides a coarse estimate of the total floor area and the principal building types for the purpose of estimating the total number of buildings by type in the BPA service area. Approximately 1,500 buildings in this sample will be in the City Light service area.

A subsample of the first stage buildings, approximately 1,500 buildings (of which 200 are likely to be located in the City Light service area), will be drawn for the survey of building characteristics administered in the second stage. An additional survey will clarify the detailed equipment properties of selected complex commercial buildings in the third stage. The first stage work is expected to be completed by 1986, the second stage by 1987, and the third stage by 1988.

This in-depth survey of commercial buildings will enhance City Light's understanding of the commercial building stock. Questions include:

- What are the building characteristics of Seattle's commercial buildings?

- Are energy intensities a function of age, use, hours of operation, size, and/or HVAC systems?

7.3.4 Commercial Building Survey (CBS)

In 1984 City Light completed a survey of 600 commercial buildings in the City Light service area. Preparation of the data for analysis, which includes merging monthly consumption data with the characteristics data, is underway. In addition, the CBS was expanded to include those buildings in which a meter was selected for the rate sample of commercial customers for the PURPA requirements. The total number of the sample included approximately 800 buildings.

These data will enhance the understanding of City Light's commercial building stock characteristics. This information, together with the BPA-sponsored studies, should provide a reasonable base upon which to expand the level of understanding of commercial building consumption and conservation potential built upon the CHEUS.

Chapter 8

ANNOTATED BIBLIOGRAPHY FOR CHEUS PRODUCTS

8.1. End-Use Loads

- Selection of Buildings and End-Use Energy Loads for Commercial Building Measurement Study, Seattle City Light, final report--October 1982.

  Documents the selection of a test building in each of the four commercial categories. Several steps were employed in arriving at a set of buildings suitable for the field test of instrumentation and conservation measures.

  Hourly End-Use Load Data Collection in Commercial Buildings Alternate Measurement Methods 1-3, Seattle City Light, final report--January 1983.

  Outlines three data collection procedures arranged in order of cost and accuracy. Objective was to define three sets of measurement methods consistent with the specifications of City Light.

- Measurement Method 4: Continuous Hourly Data Collecting, Seattle City Light, final report--November 1982.

  Discusses the general design and implementation of measurement Method 4--microprocessor-based method. The requirements were generated from two considerations: The City Light work statement and the cost of replicating the system in 10 buildings.

- Commercial Building Hourly End-Use Loads and Conservation Load Management Data - A Project of Seattle City Light, Seattle City Light, final report--November 1982.

  Describes a procedure for taking the verified building energy-use simulation and using it to analyze and identify a cost-effective set of conservation load and management strategies to implement.

- Detailed Measurement Plans, Seattle City Light, revised draft--December 1982.

  Discusses general procedure used to develop detailed measurement plans for instrumentation of buildings and, when completed, will show how these methods result in specific plans for two test buildings.

- Field Test Report, Seattle City Light, final report--March 1984.

  Report documenting work completed on the two field test sites. Discusses the procedures that were developed to collect hourly end-use load data in support of an assessment of measurements methods and conservation potential in commercial buildings. Presents the results obtained and problems encountered in the application of these procedures to the two field test buildings. Also incorporates the problems and successes encountered during the field test for future use.

- Commercial Hourly End-Use Load Study Audit Reports, Seattle City Light, spring 1985.

  A report for each CHEUS building, which includes a building description, audit observations, and an energy consumption and conservation analysis.

8.2. Simulation

- Review of Complex and Simplified Commercial Building Energy Analysis Programs, Seattle City Light, final report--September 1982.

  Provides a review and comparison of the capabilities of a set of these complex and simplified codes which are felt to be the best available alternatives to City Light. Recommended DOE 2.1 code.

- Field Data Collection Procedures for an Hourly Building Simulation Model, Seattle City Light, final report--October 1982.

  Describes the steps necessary to assemble data to run DOE 2.1 computer simulation program. Includes a discussion of personnel skill and equipment required, as well as an estimate of labor and equipment cost involved to gather the necessary information and generate the building simulation. Recommendations for making the process cost effective are also included.

- Conservation and Load Management Strategy Identification and Analysis Procedure, Seattle City Light, final report--November 1982.

  Describes the procedure for taking the building simulation and using it to analyze and identify cost-effective conservation and load management strategies. Includes a discussion of the steps necessary to identify the strategies, as well as methodology to describe characteristics. Also outlines a process for choosing the optimum set of strategies based on peak, intermediate, and base energy savings.

- Energy Conservation Analysis of Two Field Test Buildings, Seattle City Light, March 1983.

  Describes the results obtained from the application of the thermal performance and economic analyses procedures to a set of field test buildings--a nonfood retail store and an office building.

- Clarification and Re-evaluation of the Optimized Strategy Sets, Seattle City Light, August 1983.

  Describes the optimum package of conservation/load management strategies selected for each of the field test buildings. Provides the results of a re-evaluation of the initial cost estimate used in the field test, including the impacts of changes that were deemed appropriate. This re-evaluation was in response to questions raised during City Light review of the initial cost estimates. In re-evaluation, emphasis was placed on obtaining costs from vending and manufacturing price lists.

- Simulation Summary Package, Seattle City Light, fall 1984.

  Presents building characteristics, end-use schedules, and retrofit opportunities in tabular format.

- Modeling Conservation Strategies Using DEMON, Academic Computing Services, December 1985

  Describes the DEMON computer program that manages computer tasks related to the simulation and evaluation of conservation strategies. The program is used in conjunction with on-site audits and DOE 2 and collects and compares data from multiple DOE 2 runs.

8.3. Commercial Building Survey

- Commercial Building Survey: Field Data Collection Procedures, Seattle City Light, December 1983.

  Provides a description of the data collection procedures and forms used to collect building characteristics of the City Light commercial sector. Emphasized collection of as much information possible at a reasonable cost and with an acceptable level of accuracy.

8.4. Other Products

- Reports of summary statistics for channel and end-use data by month and year.

- Graphic representations of end-use shares by hour, month, and year.

- Retrofit participation agreement for building owners, by Seattle City Light, summer 1985.

- Electric billing histories presenting kilowatt-hour consumption, demand, and dollar amount of bills by month, 1980-present.

- Gas billing histories presenting thermal consumption and dollar amount of bill by month, 1980-1983.

- Energy Consumption and Conservation Opportunities, by Seattle City Light and Seton, Johnson and Odell, summer 1985. Presentation of materials used by consultant informing building owners of retrofit opportunities.

8.5. Related Publications

- Verification of Models of Commercial End-Use Loads with Metered Data, C. McDonald, Synergic Resources Corporation, and J. Wharton, Electric Power Research Institute, August 1985.

  Describes the performance of using an engineering simulation model and a statistical prorating procedure for estimating end-use load shapes, using actual loads for an office building monitored by City Light.

- Commercial Hourly End-Use Study, Workshop II Abstracts, End-Use Load and Conservation Assessment Program, Bonneville Power Administration, November 1985.

- A Beneficial Application of End-Use Load Data in Commercial Building Simulation, C. M. Cleary and M. A. Schuldt, ASHRAE, December 1985.

  Presents the results of an analysis of a lighting system modification in a retail store using two different sets of lighting inputs in the DOE 2.1A simulation model.

- Commercial End-Use Metering Workshop Proceedings, Electric Power Research Project 1216-10, January 1986.

  Describes the commercial end-use metering efforts underway in the Pacific Northwest, including the City Light project.

- Preliminary Analysis of Conservation Potential in Office Buildings, C. M. Cleary, ASHRAE, June 1986.

  Compares the results of the conservation analysis of the two office buildings selected for study with earlier estimates developed by City Light to guide the planning of new conservation programs.

8.6 Installation of the Conservation Measures

- Installation of Energy Conservation Measures in Commercial Buildings, Seattle City Light, final report--August 1986.

  Describes the experience gained and lessons learned during the implementation of the conservation strategies in the eight study buildings.

Appendix A

Building Characteristics

SUMMARY DATA: RETAIL #1

CHARACTERISTICS

Square feet	22,326
Year built	1973
Shell materials	Concrete
Principal use	Retail

Appliances

Space heat	Electric
Hot water	Electric
Air conditioning	Electric

LOADS

Billed Consumption	City Light Kwh	Gas Therms
1980	707,400	
1981	714,000	
1982	718,920	Not applicable
1983	737,280	
1984	718,920	
1985	446,920	

Use/ft2 - 6-year average in kwh	30.3
Use/ft2 - 1985	20.0
City Light forecast use/ft2	15.2
Regional forecast use/ft2	26.9

1985 Hourly End-Use Data (kwh/yr)

Electric End Uses	Kwh	Kwh/ sq.ft.	Percent
HVAC	118,260	5.3	22.3
Hot water	0	0	0
Lights	358,430	16.1	67.4
Refrigeration	0	0	0
Elevator	0	0	0
Misc equipment	54,750	2.5	10.3
TOTAL	531,440*	23.9*	100.0

CONSERVATION PACKAGE

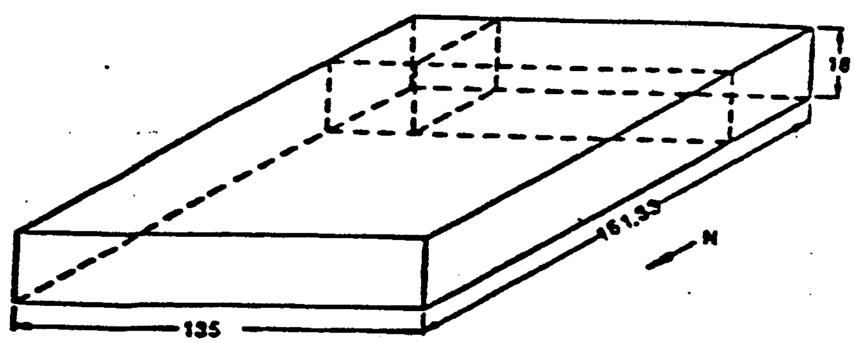
	Estimated 1984 Costs	Simple Payback	Savings
Night setback and fan schedule revisions	$ 590	0.3	Elec
Ceiling to R-19	16,312	8.3	Elec
TOTAL	$16,902	4 yrs elec N/A	

TOTAL ANNUAL ELECTRIC SAVINGS = 125.2 Mwh

Peak 6.9% Intermediate 14.4% Off Peak 78.7%

*Equipment measurement exceeded 10 percent accuracy range during months of January 1985 to July 1985.

Retail #1



CHEUS retail #1 is a drug and sundries store open for business 77 hours a week. The average number of customers per hour is 44. Built in 1973, the building is constructed of concrete block on a concrete slab on grade with a built-up roof. The total floor area is 22,326 sq.ft. The building is single storied. Eighty-two percent of this space is sales area, 11 percent is storage, and 7 percent is office. Glass represents 3.4 percent of the gross wall area. The HVAC system is comprised of a single-zone heating and cooling system with electric resistance heaters and direct expansion cooling. The system is manually controlled with thermostats set at 68° F for heating and 72° F for cooling. Sales area lighting is primarily provided by 8-foot fluorescent fixtures, which were added in late 1984 to replace the original 400-watt mercury vapor fixtures. Office lighting is fluorescent with some incandescent spots. Exterior lighting is fluorescent.

The principal end-use loads are interior lights (67.4 percent of the total electrical energy conservation), cooling (10.0 percent), outlets (10.3 percent), heating (8.0 percent), and ventilation (4.3 percent). The building uses electric energy only and consumed 446,920 kwh in 1985 with an average 145-kw demand. This facility consumes the equivalent of 103,485 Btu/sq.ft./year.

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

FEB 1983 THROUGH JUL 1983

MONTH		LIGHTS	COOLING	HEAT	OTHER	VENT	TOTAL
FEB:	PCT	65.3	13.4	12.4	5.4	4.1	100.0
	MEAN	46.1	9.5	8.8	3.8	2.9	70.6
	STDEV	33.6	8.0	16.9	1.5	2.4	41.9
	MIN	10	1	1	2	0	14
	MAX	87	31	115	10	5	136
	VALIDN	672					
MAR:	PCT	73.9	10.8	6.2	5.4	4.4	100.0
	MEAN	48.9	7.2	4.1	3.6	2.9	66.1
	STDEV	35.0	7.5	8.6	1.4	2.4	41.8
	MIN	10	0	0	2	0	12
	MAX	88	36	66	6	5	132
	VALIDN	744					
APR:	PCT	86.7	3.8	1.1	6.0	3.2	100.0
	MEAN	49.5	2.2	.6	3.4	1.8	57.1
	STDEV	35.0	3.3	.9	1.4	2.3	38.6
	MIN	10	0	0	2	0	12
	MAX	88	24	2	6	5	119
	VALIDN	719					
MAY:	PCT	76.0	12.2	2.7	5.9	4.1	100.0
	MEAN	46.5	7.5	1.6	3.6	2.5	61.2
	STDEV	33.4	9.5	.7	1.4	2.4	42.4
	MIN	9	0	0	2	0	11
	MAX	85	31	2	7	6	124
	VALIDN	479					
JUN:	PCT	68.5	20.8	2.5	4.8	4.0	100.0
	MEAN	58.2	17.7	2.1	4.1	3.4	85.0
	STDEV	21.4	11.8	.7	1.1	2.2	33.8
	MIN	15	1	1	2	0	20
	MAX	81	47	7	7	5	134
	VALIDN	222					
JUL:	PCT	60.8	24.6	4.7	4.7	5.6	100.0
	MEAN	54.7	22.1	4.2	4.3	5.0	89.9
	STDEV	26.2	10.2	3.4	.9	.1	32.8
	MIN	11	2	2	3	5	28
	MAX	82	47	16	6	6	138
	VALIDN	744					
TOT:	PCT	70.8	14.7	5.4	5.4	4.4	100.0
	MEAN	50.0	10.4	3.8	3.8	3.1	70.6
	STDEV	32.3	10.8	8.9	1.3	2.4	40.8
	MIN	9	0	0	2	0	11
	MAX	88	47	115	10	6	138
	VALIDN	3580					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1983 THROUGH DEC 1983

MONTH		LIGHTS	COOLING	HEAT	OTHER	VENT	TOTAL
JUL:	PCT	60.8	24.6	4.7	4.7	5.6	100.0
	MEAN	54.7	22.1	4.2	4.3	5.0	89.9
	STDEV	26.2	10.2	3.4	.9	.1	32.8
	MIN	11	2	2	3	5	28
	MAX	82	47	16	6	6	138
	VALIDN	744					
AUG:	PCT	62.5	25.0	3.4	4.5	5.0	100.0
	MEAN	59.5	23.8	3.3	4.3	4.8	95.2
	STDEV	24.2	10.8	2.8	.9	1.0	32.8
	MIN	14	2	1	2	0	20
	MAX	85	46	15	6	6	137
	VALIDN	744					
SEP:	PCT	64.6	20.4	5.0	4.9	5.5	100.0
	MEAN	58.4	18.4	4.5	4.5	5.0	90.4
	STDEV	25.2	10.0	4.0	.9	.1	32.0
	MIN	14	2	2	3	5	25
	MAX	84	44	19	7	6	137
	VALIDN	720					
OCT:	PCT	67.5	19.2	2.9	5.6	5.4	100.0
	MEAN	60.9	17.3	2.6	5.0	4.9	90.2
	STDEV	25.3	11.7	2.3	1.0	.8	34.5
	MIN	14	2	2	3	0	26
	MAX	86	45	19	8	6	141
	VALIDN	601					
NOV:	PCT	72.1	13.4	3.2	6.2	5.9	100.0
	MEAN	61.8	11.5	2.7	5.3	5.0	85.7
	STDEV	25.3	6.9	3.4	.9	.1	30.5
	MIN	14	2	2	3	5	26
	MAX	88	27	20	8	6	125
	VALIDN	719					
DEC:	PCT	75.2	7.2	8.0	5.6	4.5	100.0
	MEAN	69.5	6.7	7.4	5.1	4.1	92.4
	STDEV	22.8	6.2	12.1	1.2	1.8	25.3
	MIN	15	2	2	2	0	21
	MAX	92	27	65	8	6	150
	VALIDN	744					
TOT:	PCT	67.0	18.3	4.6	5.2	5.3	100.0
	MEAN	60.8	16.6	4.2	4.7	4.8	90.7
	STDEV	25.2	11.2	6.1	1.1	1.0	31.5
	MIN	11	2	1	2	0	20
	MAX	92	47	65	8	6	150
	VALIDN	4272					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1984 THROUGH JUN 1984

MONTH		LIGHTS	COOLING	HEAT	OTHER	VENT	TOTAL
JAN:	PCT	78.8	6.7	5.2	6.0	3.8	100.0
	MEAN	61.6	5.3	4.1	4.7	3.0	78.1
	STDEV	27.6	4.9	7.9	1.6	2.4	32.1
	MIN	15	2	2	2	0	20
	MAX	91	24	59	8	6	120
	VALIDN	744					
FEB:	PCT	77.7	8.2	4.6	6.1	4.1	100.0
	MEAN	56.4	6.0	3.3	4.4	2.9	72.5
	STDEV	31.0	5.3	5.6	1.6	2.4	37.3
	MIN	14	2	2	2	0	20
	MAX	90	21	42	8	6	121
	VALIDN	694					
MAR:	PCT	76.5	10.5	4.0	5.8	4.0	100.0
	MEAN	55.8	7.6	2.9	4.2	2.9	72.9
	STDEV	30.3	7.1	4.8	1.5	2.4	38.6
	MIN	15	2	2	2	0	20
	MAX	89	27	60	8	6	126
	VALIDN	743					
APR:	PCT	74.6	14.6	2.7	5.3	3.5	100.0
	MEAN	62.1	12.2	2.3	4.4	2.9	83.3
	STDEV	29.2	11.5	2.2	1.6	2.4	40.9
	MIN	15	2	1	2	0	19
	MAX	92	46	30	7	6	150
	VALIDN	718					
MAY:	PCT	66.8	23.7	2.2	4.7	3.2	100.0
	MEAN	61.9	21.9	2.0	4.3	3.0	92.6
	STDEV	27.4	17.7	.0	1.5	2.4	45.8
	MIN	14	2	2	2	0	20
	MAX	91	48	2	7	5	148
	VALIDN	736					
JUN:	PCT	64.0	25.9	2.2	4.7	3.6	100.0
	MEAN	57.6	23.3	2.0	4.2	3.3	89.9
	STDEV	30.2	17.1	.2	1.3	2.3	44.4
	MIN	15	2	2	2	0	20
	MAX	88	54	6	6	6	152
	VALIDN	719					
TOT:	PCT	72.6	15.6	3.4	5.4	3.7	100.0
	MEAN	59.2	12.7	2.8	4.4	3.0	81.6
	STDEV	29.4	13.9	4.6	1.5	2.4	40.8
	MIN	14	2	1	2	0	19
	MAX	92	54	60	8	6	152
	VALIDN	4354					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1984 THROUGH DEC 1984

MONTH		LIGHTS	COOLING	HEAT	OTHER	VENT	TOTAL
JUL:	PCT	62.2	27.5	2.2	4.8	3.8	100.0
	MEAN	58.0	25.6	2.1	4.4	3.6	93.2
	STDEV	30.6	17.3	.6	1.3	2.2	46.3
	MIN	14	2	2	2	0	19
	MAX	90	56	8	7	6	154
	VALIDN	743					
AUG:	PCT	64.3	26.1	2.1	4.8	3.2	100.0
	MEAN	61.5	25.0	2.0	4.6	3.0	95.6
	STDEV	27.4	19.4	.2	1.6	2.4	45.7
	MIN	12	1	0	2	0	18
	MAX	90	70	6	8	5	162
	VALIDN	743					
SEP:	PCT	66.6	22.8	2.1	5.6	3.4	100.0
	MEAN	62.7	21.5	2.0	5.2	3.2	94.1
	STDEV	27.5	17.0	.3	1.4	2.3	41.8
	MIN	12	2	1	2	0	18
	MAX	88	53	8	8	6	149
	VALIDN	720					
OCT:	PCT	72.2	16.6	2.2	6.0	3.5	100.0
	MEAN	67.6	15.6	2.1	5.7	3.2	93.7
	STDEV	24.4	13.7	.8	1.3	2.3	34.8
	MIN	12	2	2	2	0	20
	MAX	89	50	18	8	6	144
	VALIDN	744					
NOV:	PCT	74.5	7.1	4.0	11.6	4.0	100.0
	MEAN	38.1	3.6	2.0	5.9	2.0	51.1
	STDEV	14.9	4.9	.4	2.1	2.5	17.8
	MIN	9	2	2	3	0	15
	MAX	73	29	8	18	6	101
	VALIDN	719					
DEC:	PCT	72.9	3.3	7.6	14.8	2.5	100.0
	MEAN	43.6	2.0	4.5	8.8	1.5	59.8
	STDEV	17.6	.1	9.8	4.4	2.0	21.5
	MIN	9	1	0	3	0	16
	MAX	65	2	64	20	6	140
	VALIDN	744					
TOT:	PCT	68.0	19.1	3.0	7.1	3.4	100.0
	MEAN	55.3	15.6	2.5	5.8	2.8	81.3
	STDEV	26.6	17.0	4.2	2.7	2.4	40.8
	MIN	9	1	0	2	0	15
	MAX	90	70	64	20	6	162
	VALIDN	4413					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1985 THROUGH JUN 1985

MONTH		LIGHTS	COOLING	HEAT	OTHER	VENT	TOTAL
JAN:	PCT	73.9	2.9	10.9	9.9	3.3	100.0
	MEAN	53.2	2.1	7.9	7.1	2.4	72.0
	STDEV	20.1	.8	13.7	3.5	2.3	21.7
	MIN	10	2	2	3	0	17
	MAX	68	18	68	19	6	139
	VALIDN	744					
FEB:	PCT	75.2	2.7	10.9	10.2	2.0	100.0
	MEAN	55.1	2.0	8.0	7.5	1.5	73.2
	STDEV	19.0	.0	13.0	2.5	1.4	18.6
	MIN	13	2	2	4	0	23
	MAX	68	2	67	13	3	139
	VALIDN	336					
MAR:	PCT	78.3	5.4	4.8	8.8	3.5	100.0
	MEAN	53.9	3.7	3.3	6.1	2.4	68.9
	STDEV	18.6	5.3	6.0	1.5	2.4	21.8
	MIN	13	1	2	3	0	19
	MAX	67	24	55	13	5	114
	VALIDN	559					
APR:	PCT	76.7	8.8	3.6	8.8	3.0	100.0
	MEAN	52.5	6.0	2.4	6.0	2.1	68.4
	STDEV	19.2	8.0	3.0	1.4	2.4	25.0
	MIN	12	2	2	3	0	19
	MAX	74	32	40	13	6	118
	VALIDN	717					
MAY:	PCT	66.4	14.3	4.7	10.5	5.1	100.0
	MEAN	37.1	8.0	2.6	5.9	2.9	55.9
	STDEV	16.0	8.1	3.6	1.6	2.4	24.9
	MIN	10	2	1	3	0	16
	MAX	54	30	40	9	5	107
	VALIDN	743					
JUN:	PCT	63.5	17.0	4.1	11.9	5.1	100.0
	MEAN	30.7	8.2	2.0	5.8	2.5	48.3
	STDEV	17.4	7.7	.0	2.2	2.4	28.2
	MIN	11	2	2	3	0	17
	MAX	52	36	2	10	5	97
	VALIDN	150					
TOT:	PCT	73.7	7.4	6.7	9.7	3.5	100.0
	MEAN	48.7	4.9	4.4	6.4	2.3	66.0
	STDEV	20.1	6.5	8.8	2.4	2.3	24.4
	MIN	10	1	1	3	0	16
	MAX	74	36	68	19	6	139
	VALIDN	3249					

AVERAGE HOURLY KWH FOR THE COMMERCIAL HOURLY END-USE STUDY BY MONTH

JUL 1985 THROUGH DEC 1985

MONTH		LIGHTS	COOLING	HEAT	OTHER	VENT	TOTAL
JUL:	PCT	55.6	25.6	3.4	10.0	6.0	100.0
	MEAN	31.8	14.7	1.9	5.7	3.4	57.3
	STDEV	17.2	10.3	.3	1.8	2.1	28.7
	MIN	10	1	0	3	0	14
	MAX	49	43	2	8	5	103
	VALIDN	682					
AUG:	PCT	58.5	22.9	3.2	9.9	5.7	100.0
	MEAN	36.6	14.3	2.0	6.2	3.6	62.6
	STDEV	15.2	11.8	.1	1.3	2.2	26.8
	MIN	10	1	0	3	0	14
	MAX	55	45	2	8	6	106
	VALIDN	742					
SEP:	PCT	64.5	15.4	4.0	10.8	5.6	100.0
	MEAN	32.4	7.7	2.0	5.4	2.8	50.3
	STDEV	17.8	8.4	.0	1.7	2.4	27.2
	MIN	10	1	1	3	0	16
	MAX	56	35	2	8	6	102
	VALIDN	718					
OCT:	PCT	71.7	7.4	4.3	11.3	5.6	100.0
	MEAN	33.5	3.4	2.0	5.3	2.6	46.7
	STDEV	19.2	4.3	.0	1.7	2.5	24.1
	MIN	10	1	2	3	0	16
	MAX	56	20	2	12	6	84
	VALIDN	743					
NOV:	PCT	62.6	2.7	13.8	14.7	6.4	100.0
	MEAN	37.1	1.6	8.2	8.7	3.8	59.2
	STDEV	19.4	1.9	20.9	4.5	2.2	35.0
	MIN	10	1	0	3	0	16
	MAX	59	15	133	20	6	215
	VALIDN	718					
DEC:	PCT	59.5	2.0	25.7	10.1	2.7	100.0
	MEAN	38.0	1.3	16.4	6.5	1.7	63.9
	STDEV	20.0	1.3	28.5	2.7	2.4	42.7
	MIN	11	1	0	3	0	16
	MAX	59	11	134	19	6	210
	VALIDN	740					
TOT:	PCT	61.7	12.5	9.6	11.1	5.3	100.0
	MEAN	34.9	7.1	5.5	6.3	3.0	56.7
	STDEV	18.4	9.3	15.5	2.7	2.4	32.0
	MIN	10	1	0	3	0	14
	MAX	59	45	134	20	6	215
	VALIDN	4343					

SUMMARY DATA: RETAIL #2

CHARACTERISTICS

Square feet	36,862
Year built	1962
Shell materials	Concrete
Principal use	Retail
Appliances	
Space Heat	Gas
Hot water	Electric

LOADS

Billed consumption	City Light Kwh	Gas Therms
1980	598,072	8,888.30
1981	654,391	8,266.00
1982	622,114	14,146.6
1983	845,607	17,410.3
1984	786,318	Not available
1985	613,898	Not available
Use/ft2 - 6-year average in kwh	18.6	9.7
Use/ft2 - 1985	16.7	
City Light forecast use/ft2	13.5	
Regional forecast use/ft2	26.9	

1985 Hourly End-Use Data (kwh/yr)

Electric End Uses	Kwh	Kwh/ sq.ft.	Percent
HVAC	959	0	0
Hot water	2,920	0.1	.5
Lights	562,100	15.3	89.6
Refrigeration	0	0	0
Elevator	0	0	0
Misc equipment	62,050	1.7	9.9
TOTAL	628,029*	17.1*	100.0

CONSERVATION PACKAGE

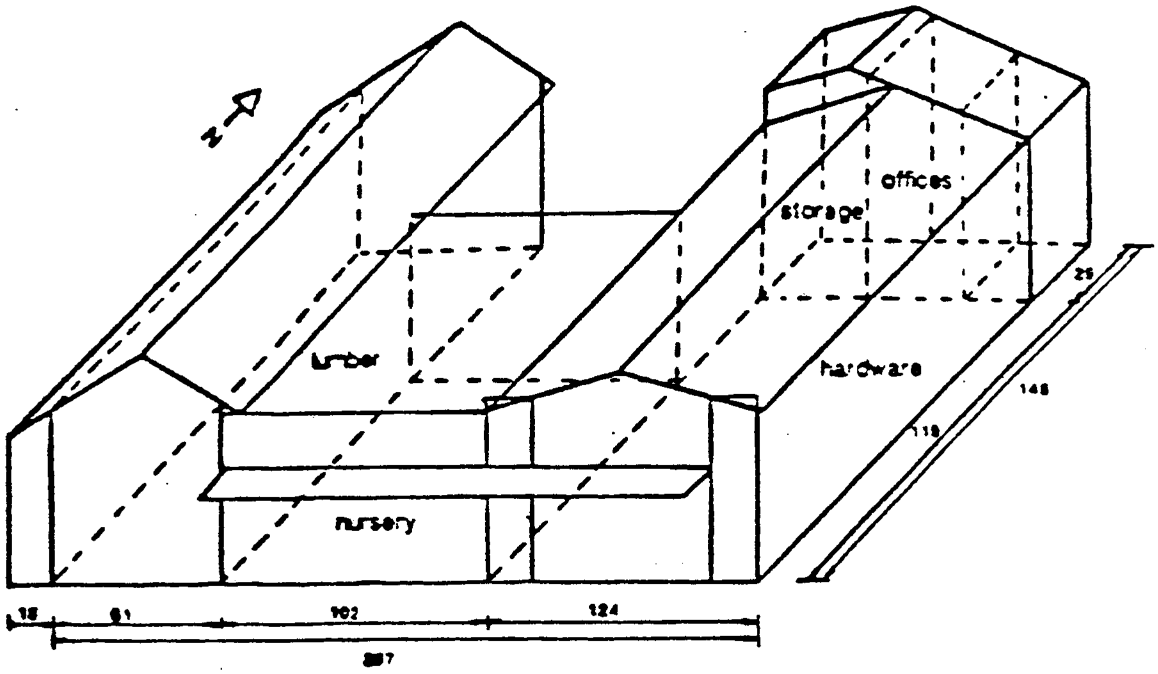
	Estimated 1984 Costs	Simple Payback	Savings
Light level reduction	$ 4,212	2.5	Elec
Roof fans lockout	793	0.3	Gas
Loading doors seals	233	0.3	Gas
Interior light controls	2,277	3.7	Elec
Unit heater lockout	1,335	0.7	Gas
Night setback	2,666	0.9	Gas
Exterior light controls	667	4.9	Elec
TOTAL	$12,183	10 yrs elec 1 yr gas	

TOTAL ANNUAL ELECTRIC SAVINGS =

Peak 1.7% Intermediate 9.1% Off Peak 98.2%

*Within the accuracy range of the monitoring equipment.

Retail #2



CHEUS retail #2 is a store specializing in hardware, gardening supplies, and lumber that is open 81 hours a week. The average number of customers per hour is 164. Built in 1962 with modifications made in 1972, the building has a wood frame, a roof built up over a plywood deck, and walls constructed of concrete block. The building is a "U" shape that incorporates three rectangular-shaped buildings. The total floor area is 36,682 sq.ft. over a single story. Ninety-one percent of this space is sales area and 9 percent is office and storage. Glass makes up 2.5 percent of the gross wall area. The heating system consists of 23 gas-fired unit heaters that are manually controlled with thermostats set at 68° F. Cooling is controlled by roof exhaust fans during the summer months only. Interior lighting is fluorescent. Exterior lighting is a mix of incandescent, fluorescent, and mercury vapor.

The principal end-use loads are interior lights (88.2 percent of the total electrical energy consumption), outlets (9.9 percent), exterior lights (1.4 percent), and hot water (0.5 percent). Although natural gas is used for space heating, all other end uses (exterior lights, ventilation, hot water, outlets) are electrical. The 1985 annual electrical consumption was 613,898 kwh with an average 130-kw demand. The average annual natural gas consumption is approximately 11,862 therms (9.7 kwh/sq.ft. equivalent). This facility consumes the equivalent of 96,690 Btu/sq.ft./year.

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1983 THROUGH DEC 1983

MONTH		LIGHTS	OUTLETS	XLIGHTS	VENT	HOT WATER	TOTAL
JUL:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
AUG:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
SEP:	PCT	91.6	5.7	1.5	.5	.4	100.0
	MEAN	85.3	5.3	1.4	.5	.4	93.0
	STDEV	36.2	1.5	2.5	.5	.7	38.5
	MIN	14	2	0	0	0	17
	MAX	120	8	7	1	3	133
	VALIDN	720					
OCT:	PCT	91.8	6.1	1.5	.0	.5	100.0
	MEAN	87.3	5.8	1.5	.0	.4	95.1
	STDEV	39.7	1.8	2.6	.0	.8	41.7
	MIN	12	2	0	0	0	16
	MAX	121	10	7	0	3	137
	VALIDN	574					
NOV:	PCT	90.0	7.9	1.5	.0	.5	100.0
	MEAN	97.2	8.6	1.7	.0	.5	108.0
	STDEV	37.5	2.5	2.9	.0	.8	40.0
	MIN	17	3	0	0	0	22
	MAX	130	15	8	0	3	152
	VALIDN	646					
DEC:	PCT	87.7	10.3	1.5	.0	.5	100.0
	MEAN	101.7	12.0	1.7	.0	.6	116.0
	STDEV	38.8	2.3	3.0	.0	.9	41.7
	MIN	16	4	0	0	0	23
	MAX	131	18	8	0	3	155
	VALIDN	743					
TOT:	PCT	90.0	7.8	1.5	.1	.5	100.0
	MEAN	93.1	8.1	1.6	.1	.5	103.4
	STDEV	38.6	3.4	2.7	.3	.8	41.6
	MIN	12	2	0	0	0	16
	MAX	131	18	8	1	3	155
	VALIDN	2683					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1984 THROUGH JUN 1984

MONTH		LIGHTS	OUTLETS	XLIGHTS	VENT	HOT WATER	TOTAL
JAN:	PCT	90.5	7.3	1.6	.0	.6	100.0
	MEAN	92.6	7.4	1.6	.0	.6	102.3
	STDEV	43.3	2.4	2.9	.1	.9	46.1
	MIN	16	2	0	0	0	18
	MAX	132	14	8	1	3	151
	VALIDN	744					
FEB:	PCT	91.2	6.6	1.6	.0	.5	100.0
	MEAN	92.5	6.7	1.7	.0	.5	101.4
	STDEV	41.9	2.3	2.9	.0	.8	44.8
	MIN	13	2	0	0	0	15
	MAX	130	13	8	0	3	147
	VALIDN	694					
MAR:	PCT	90.5	7.1	1.9	.0	.5	100.0
	MEAN	80.5	6.3	1.7	.0	.4	88.9
	STDEV	45.6	1.9	3.0	.0	.8	48.6
	MIN	15	3	0	0	0	18
	MAX	127	11	8	0	3	145
	VALIDN	643					
APR:	PCT	89.8	7.6	2.0	.0	.6	100.0
	MEAN	81.9	7.0	1.8	.0	.5	91.2
	STDEV	45.1	2.1	3.1	.0	.8	48.4
	MIN	16	3	0	0	0	21
	MAX	125	11	8	0	3	145
	VALIDN	298					
MAY:	PCT	90.6	6.8	1.9	.1	.5	100.0
	MEAN	79.1	6.0	1.7	.1	.4	87.3
	STDEV	43.8	1.9	3.0	.2	.7	46.8
	MIN	12	2	0	0	0	16
	MAX	125	10	8	1	3	141
	VALIDN	743					
JUN:	PCT	89.8	7.1	2.1	.5	.4	100.0
	MEAN	78.7	6.2	1.8	.4	.4	87.7
	STDEV	40.7	2.1	2.6	.5	.7	43.8
	MIN	9	2	0	0	0	11
	MAX	121	11	8	1	3	141
	VALIDN	719					
TOT:	PCT	90.5	7.0	1.8	.1	.5	100.0
	MEAN	84.5	6.6	1.7	.1	.5	93.4
	STDEV	43.6	2.2	2.9	.3	.8	46.6
	MIN	9	2	0	0	0	11
	MAX	132	14	8	1	3	151
	VALIDN	3841					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1984 THROUGH DEC 1984

MONTH		LIGHTS	OUTLETS	XLIGHTS	VENT	HOT WATER	TOTAL
JUL:	PCT	89.2	7.7	2.0	.6	.4	100.0
	MEAN	73.5	6.3	1.6	.5	.3	82.4
	STDEV	38.3	2.0	2.1	.5	.7	40.9
	MIN	11	2	0	0	0	14
	MAX	118	11	6	1	3	127
	VALIDN	556					
AUG:	PCT	89.0	7.7	1.9	.7	.4	100.0
	MEAN	73.1	6.4	1.6	.6	.4	82.2
	STDEV	38.5	1.7	2.1	.5	.7	41.1
	MIN	16	3	0	0	0	20
	MAX	115	11	6	1	3	128
	VALIDN	323					
SEP:	PCT	90.6	6.8	2.0	.2	.4	100.0
	MEAN	74.1	5.5	1.6	.2	.3	81.8
	STDEV	39.5	1.4	2.2	.4	.7	41.6
	MIN	13	3	0	0	0	17
	MAX	116	9	7	1	3	131
	VALIDN	564					
OCT:	PCT	89.5	8.1	1.8	.0	.5	100.0
	MEAN	74.1	6.7	1.5	.0	.4	82.8
	STDEV	41.0	2.1	2.7	.0	.8	44.0
	MIN	12	2	0	0	0	17
	MAX	116	13	7	0	3	135
	VALIDN	744					
NOV:	PCT	89.1	8.7	1.7	.0	.5	100.0
	MEAN	72.0	7.0	1.4	.0	.4	80.8
	STDEV	41.6	2.4	2.5	.0	.8	45.0
	MIN	12	1	0	0	0	13
	MAX	115	13	7	0	3	137
	VALIDN	720					
DEC:	PCT	87.2	9.6	2.6	.0	.7	100.0
	MEAN	71.8	7.9	2.1	.0	.5	82.3
	STDEV	43.2	2.2	2.7	.0	.9	46.5
	MIN	15	3	0	0	0	19
	MAX	121	14	7	0	3	141
	VALIDN	744					
TOT:	PCT	89.0	8.2	2.0	.2	.5	100.0
	MEAN	73.0	6.7	1.6	.2	.4	82.0
	STDEV	40.7	2.2	2.5	.4	.8	43.6
	MIN	11	1	0	0	0	13
	MAX	121	14	7	1	3	141
	VALIDN	3651					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1985 THROUGH JUN 1985

MONTH		LIGHTS	OUTLETS	XLIGHTS	VENTHOT	WATER	TOTAL
JAN:	PCT	89.3	7.7	2.2	.0	.7	100.0
	MEAN	73.3	6.3	1.8	.0	.6	82.1
	STDEV	41.3	2.0	2.8	.0	1.0	44.6
	MIN	12	3	0	0	0	14
	MAX	117	12	7	0	3	136
	VALIDN	729					
FEB:	PCT	86.6	10.5	2.1	.0	.8	100.0
	MEAN	66.2	8.0	1.6	.0	.6	76.5
	STDEV	44.1	2.0	2.7	.0	.9	47.9
	MIN	9	5	0	0	0	13
	MAX	113	11	7	0	3	132
	VALIDN	264					
MAR:	PCT	86.4	10.2	2.4	.0	.9	100.0
	MEAN	64.7	7.6	1.8	.0	.7	74.9
	STDEV	40.5	1.9	2.5	.0	1.0	43.2
	MIN	8	4	0	0	0	13
	MAX	110	11	8	0	3	128
	VALIDN	466					
APR:	PCT	87.2	9.7	2.3	.0	.7	100.0
	MEAN	62.6	7.0	1.7	.0	.5	71.7
	STDEV	43.8	2.0	2.4	.1	.8	46.6
	MIN	5	3	0	0	0	10
	MAX	116	11	8	1	3	135
	VALIDN	718					
MAY:	PCT	89.4	9.3	.6	.0	.6	100.0
	MEAN	62.9	6.6	.4	.0	.5	70.4
	STDEV	42.8	1.9	1.4	.1	.8	45.1
	MIN	6	3	0	0	0	10
	MAX	117	11	7	1	3	134
	VALIDN	743					
JUN:	PCT	89.1	9.4	.5	.2	.5	100.0
	MEAN	59.7	6.3	.4	.1	.4	67.0
	STDEV	43.3	1.5	1.5	.4	.7	45.1
	MIN	5	3	0	0	0	10
	MAX	115	9	7	1	3	132
	VALIDN	719					
TOT:	PCT	88.3	9.3	1.6	.0	.7	100.0
	MEAN	64.8	6.8	1.2	.0	.5	73.3
	STDEV	42.8	2.0	2.3	.2	.9	45.5
	MIN	5	3	0	0	0	10
	MAX	117	12	8	1	3	136
	VALIDN	3639					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1985 THROUGH DEC 1985

MONTH		LIGHTS	OUTLETS	XLIGHTS	VENT	HT WATER	TOTAL
JUL:	PCT	88.9	9.9	.0	.7	.5	100.0
	MEAN	59.0	6.6	.0	.4	.3	66.4
	STDEV	42.0	1.7	.0	.5	.7	44.3
	MIN	7	3	0	0	0	11
	MAX	105	10	0	1	3	116
	VALIDN	742					
AUG:	PCT	89.4	9.3	.4	.3	.5	100.0
	MEAN	59.3	6.2	.3	.2	.3	66.3
	STDEV	40.2	1.5	1.3	.4	.7	41.9
	MIN	9	3	0	0	0	13
	MAX	112	9	7	1	3	125
	VALIDN	740					
SEP:	PCT	90.1	8.4	1.1	.0	.5	100.0
	MEAN	62.6	5.9	.7	.0	.3	69.5
	STDEV	40.5	1.5	2.0	.1	.7	42.6
	MIN	12	0	0	0	0	13
	MAX	113	9	7	1	3	131
	VALIDN	718					
OCT:	PCT	89.2	9.1	1.2	.0	.5	100.0
	MEAN	62.3	6.4	.8	.0	.4	69.8
	STDEV	42.8	1.8	2.1	.1	.7	45.5
	MIN	10	3	0	0	0	14
	MAX	114	10	7	1	3	132
	VALIDN	743					
NOV:	PCT	85.8	12.0	1.6	.0	.6	100.0
	MEAN	59.3	8.3	1.1	.0	.4	69.1
	STDEV	45.3	2.2	2.4	.0	.8	48.6
	MIN	6	4	0	0	0	14
	MAX	121	14	7	0	3	139
	VALIDN	717					
DEC:	PCT	84.5	13.3	1.6	.0	.6	100.0
	MEAN	65.8	10.4	1.2	.0	.5	77.8
	STDEV	46.7	2.0	2.5	.0	.9	49.9
	MIN	12	6	0	0	0	19
	MAX	122	15	7	0	3	145
	VALIDN	739					
TOT:	PCT	87.9	10.4	1.0	.2	.5	100.0
	MEAN	61.4	7.3	.7	.1	.4	69.8
	STDEV	43.0	2.4	2.0	.3	.8	45.7
	MIN	6	0	0	0	0	11
	MAX	122	15	7	1	3	145
	VALIDN	4399					

SUMMARY DATA: OFFICE #1

CHARACTERISTICS

Square feet	89,550
Year built	1979
Shell materials	Concrete
Principal use	Office

Appliances	
Space Heat	Electric heat pump
Hot water	Electric

LOADS

Billed consumption	City Light Kwh	Gas Therms
1980	2,032,200	
1981	2,166,300	
1982	2,247,300	Not applicable
1983	1,806,300	
1984	1,903,500	
1985	1,413,900	

Use/ft2 - 6-year average in kwh	21.5
Use/ft2 - 1985	15.8
City Light forecast use/ft2	17.4
Regional forecast use/ft2	24.6

1985 Hourly End-Use Data (kwh/yr)

Electric End Uses	Kwh	Kwh/ sq.ft.	Percent
HVAC	649,116	7.2	47.9
Hot water	0	0	0
Lights	466,032	5.2	34.4
Refrigeration	0	0	0
Elevator	0	0	0
Misc equipment	239,148	2.7	17.7
TOTAL	1,354,296*	15.1	100.0

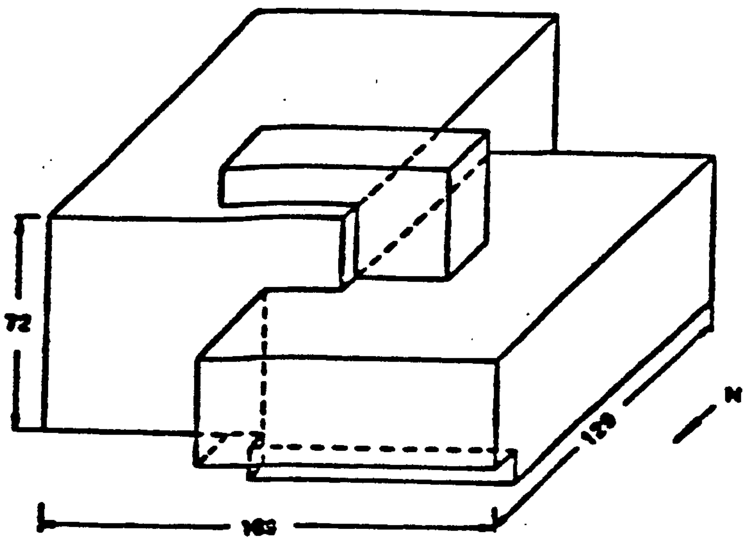
CONSERVATION PACKAGE	Estimated 1984 Costs	Simple Payback	Savings
Vent controls	$ 7,721	2.8	Elec
Optimum heat recovery	466	1.4	Elec
Perimeter light switches	11,882	9.3	Elec
Motion detectors	34,931	4.3	Elec
Roof to R-20	36,111	18.1	Elec
Reflective window film	45,147	7.3	Elec
Domestic hot water optimization	737	25.9	Elec
TOTAL	$136,995	7 yrs elec N/A	

ESTIMATED ANNUAL ELECTRIC SAVINGS = 765.3 Mwh

Peak 2.2% Intermediate 9.9% Off Peak 87.9%

*Within the accuracy range of the monitoring equipment.

Office #1



CHEUS office #1 is a six-story building that is typically occupied 50 hours a week, 8 a.m. to 6 p.m., Monday through Friday. The average occupancy level is 400 people. Built in 1976, the building was constructed in two rectangular sections, one four stories and the other six. The structure was built on a concrete slab with precast concrete walls. The total floor area is 89,550 sq.ft. Forty-seven percent of the gross wall area is glass. Heating and cooling is provided by 97 hydronic heat pumps that operate 24 hours a day. Ventilation is provided by a heat recovery system and resistance duct heater which tempers outside air and operates for 15 hours on weekdays only. Lighting is predominantly fluorescent with some incandescent spots.

The principal end-use loads are lights (34.4 percent of the total energy consumption); heat-pump system, heating and cooling (47.9 percent); and office equipment (17.7 percent). The building consumes the equivalent of 73,460 Btu/sq.ft./year. In 1985, the all-electric facility consumed 1,413,900 kwh with an average monthly demand of 410 kw.

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

FEB 1983 THROUGH JUL 1983

MONTH		LIGHTS	HPUMP	HEAT	OUTLETS	VENT	COOLING	TOTAL
FEB:	PCT	44.0	23.0	11.3	19.7	1.9	.2	100.0
	MEAN	76.2	39.8	19.5	34.1	3.3	.3	173.2
	STDEV	55.2	25.5	26.7	11.2	5.0	1.2	103.7
	MIN	3	12	0	17	0	0	53
	MAX	184	102	153	57	12	7	416
	VALIDN	671						
MAR:	PCT	42.2	25.9	10.6	18.1	2.8	.4	100.0
	MEAN	79.9	49.0	20.1	34.2	5.3	.8	189.2
	STDEV	52.7	31.9	26.0	12.4	5.5	1.9	99.8
	MIN	8	19	2	16	0	0	51
	MAX	170	109	164	58	12	7	399
	VALIDN	742						
APR:	PCT	42.3	25.7	10.8	17.9	2.3	.9	100.0
	MEAN	79.1	48.0	20.2	33.5	4.3	1.7	186.9
	STDEV	58.0	32.4	34.6	12.1	5.3	2.7	108.3
	MIN	7	19	2	17	0	0	50
	MAX	181	111	189	60	12	8	430
	VALIDN	612						
MAY:	PCT	47.3	27.1	3.7	19.2	1.5	1.2	100.0
	MEAN	83.8	47.9	6.5	34.0	2.6	2.2	177.0
	STDEV	58.5	32.7	11.8	12.3	4.5	3.0	109.8
	MIN	8	19	2	17	0	0	51
	MAX	187	108	70	57	12	8	384
	VALIDN	353						
JUN:	PCT	44.8	29.4	1.9	17.6	4.3	1.9	100.0
	MEAN	90.5	59.4	3.9	35.7	8.7	3.9	202.1
	STDEV	71.6	42.4	7.1	12.8	4.5	3.7	125.7
	MIN	6	21	2	18	0	0	50
	MAX	209	129	46	60	12	9	416
	VALIDN	198						
JUL:	PCT	46.0	30.1	1.7	17.7	2.3	2.2	100.0
	MEAN	87.5	57.2	3.3	33.8	4.3	4.2	190.3
	STDEV	67.7	41.4	4.6	14.1	5.3	3.6	122.9
	MIN	6	13	2	18	0	0	51
	MAX	225	131	35	72	12	10	431
	VALIDN	580						
TOT:	PCT	44.0	26.4	7 8	18.4	2.4	1.0	100.0
	MEAN	81.5	48.9	14.4	34.0	4.4	1.8	185.0
	STDEV	59.3	34.1	24.9	12.5	5.3	3.0	109.8
	MIN	3	12	0	16	0	0	50
	MAX	225	131	189	72	12	10	431
	VALIDN	3156						

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1983 THROUGH DEC 1983

MONTH		LIGHTS	HPUMP	HEAT	OUTLETS	VENT	COOLING	TOTAL
JUL:	PCT	46.0	30.1	1.7	17.7	2.3	2.2	100.0
	MEAN	87.5	57.2	3.3	33.8	4.3	4.2	190.3
	STDEV	67.7	41.4	4.6	14.1	5.3	3.6	122.9
	MIN	6	13	2	18	0	0	51
	MAX	225	131	35	72	12	10	431
	VALIDN	580						
AUG:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
SEP:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
OCT:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
NOV:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
DEC:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
TOT:	PCT	46.0	30.1	1.7	17.7	2.3	2.2	100.0
	MEAN	87.5	57.2	3.3	33.8	4.3	4.2	190.3
	STDEV	67.7	41.4	4.6	14.1	5.3	3.6	122.9
	MIN	6	13	2	18	0	0	51
	MAX	225	131	35	72	12	10	431
	VALIDN	580						

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1984 THROUGH JUN 1984

MONTH		LIGHTS	HPUMP	HEAT	OUTLETS	VENT	COOLING	TOTAL
JAN:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
FEB:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
MAR:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
APR:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
MAY:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
JUN:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						
TOT:	PCT	.0	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0	0
	VALIDN	0						

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1984 THROUGH DEC 1984

MONTH		LIGHTS	HPUMP	HEAT	OUTLETS	VENT	COOLING	TOTAL
JUL:	PCT	33.6	36.5	6.5	17.2	2.0	4.2	100.0
	MEAN	76.4	83.0	14.7	39.1	4.6	9.7	227.6
	STDEV	54.9	46.9	25.5	14.5	7.2	6.2	121.7
	MIN	15	22	2	21	0	0	78
	MAX	209	185	89	65	17	17	462
	VALIDN	338						
AUG:	PCT	41.8	30.9	6.4	15.7	1.6	3.4	100.0
	MEAN	75.0	55.5	11.5	28.2	2.9	6.1	179.3
	STDEV	48.5	37.2	13.8	8.3	4.7	3.1	94.1
	MIN	20	21	2	14	0	0	67
	MAX	185	127	64	45	12	9	369
	VALIDN	628						
SEP:	PCT	37.7	33.0	7.1	17.7	1.8	2.6	100.0
	MEAN	61.1	53.4	11.6	28.7	3.0	4.3	162.0
	STDEV	39.8	34.1	19.5	9.0	4.9	3.4	93.0
	MIN	11	21	0	17	0	0	55
	MAX	148	127	96	47	12	9	356
	VALIDN	384						
OCT:	PCT	31.0	24.2	26.7	15.8	2.2	.2	100.0
	MEAN	48.4	37.8	41.7	24.8	3.4	.3	156.4
	STDEV	30.3	22.3	44.4	8.5	5.2	.8	97.2
	MIN	0	14	0	13	0	0	48
	MAX	136	90	162	44	12	3	391
	VALIDN	374						
NOV:	PCT	22.7	24.9	35.5	14.9	1.9	.0	100.0
	MEAN	36.7	40.3	57.3	24.0	3.1	.1	161.4
	STDEV	28.7	23.7	50.8	8.0	5.0	.4	104.0
	MIN	0	16	0	6	0	0	53
	MAX	128	100	216	43	12	3	420
	VALIDN	719						
DEC:	PCT	21.3	25.9	38.8	12.7	1.1	.2	100.0
	MEAN	41.0	50.0	74.8	24.5	2.1	.3	192.7
	STDEV	24.8	26.4	47.8	8.8	4.4	.5	96.0
	MIN	8	16	0	12	0	0	61
	MAX	108	104	219	53	12	2	475
	VALIDN	744						
TOT:	PCT	30.1	28.7	22.7	15.2	1.7	1.6	100.0
	MEAN	53.8	51.4	40.5	27.2	3.0	2.9	178.8
	STDEV	40.8	33.9	46.6	10.3	5.1	4.3	102.5
	MIN	0	14	0	6	0	0	48
	MAX	209	185	219	65	17	17	475
	VALIDN	3187						

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1985 THROUGH JUN 1985

MONTH		LIGHTS	HPUMP	HEAT	OUTLETS	VENT	COOLING	TOTAL
JAN:	PCT	25.1	30.6	30.0	13.2	1.0	.0	100.0
	MEAN	48.8	59.7	58.5	25.7	2.0	.1	194.9
	STDEV	19.4	16.9	34.9	9.3	4.2	.3	64.2
	MIN	3	28	0	13	0	0	99
	MAX	122	108	180	46	12	2	382
	VALIDN	744						
FEB:	PCT	25.3	33.1	26.0	14.6	1.0	.0	100.0
	MEAN	43.5	57.2	44.9	25.1	1.7	.1	172.4
	STDEV	22.0	26.9	33.3	9.1	3.9	.3	74.0
	MIN	6	18	0	13	0	0	47
	MAX	93	101	145	48	12	2	340
	VALIDN	671						
MAR:	PCT	30.0	27.4	22.5	18.0	2.0	.1	100.0
	MEAN	41.5	37.8	31.1	24.8	2.7	.1	138.1
	STDEV	25.5	23.0	32.3	9.7	4.8	.5	82.1
	MIN	9	14	0	11	0	0	41
	MAX	95	100	176	51	12	3	352
	VALIDN	743						
APR:	PCT	33.9	28.7	13.7	21.2	2.3	.3	100.0
	MEAN	40.5	34.3	16.4	25.4	2.7	.3	119.6
	STDEV	28.2	21.3	25.1	10.0	4.8	1.0	76.5
	MIN	0	14	0	12	0	0	41
	MAX	139	92	117	47	12	8	313
	VALIDN	717						
MAY:	PCT	38.4	30.1	4.9	22.5	2.3	1.8	100.0
	MEAN	43.8	34.3	5.6	25.6	2.6	2.0	113.9
	STDEV	33.7	24.3	10.6	9.2	4.6	3.1	73.2
	MIN	0	4	0	8	0	0	35
	MAX	136	98	62	46	12	9	292
	VALIDN	729						
JUN:	PCT	36.4	30.0	4.8	21.8	2.5	4.5	100.0
	MEAN	43.3	35.7	5.7	25.9	2.9	5.4	119.0
	STDEV	36.2	25.9	12.1	9.2	4.9	3.8	77.3
	MIN	6	14	0	13	0	0	43
	MAX	132	115	73	46	12	9	295
	VALIDN	719						
TOT:	PCT	30.5	30.1	18.9	17.8	1.7	.9	100.0
	MEAN	43.6	43.0	27.0	25.4	2.5	1.3	142.9
	STDEV	28.3	25.6	33.2	9.4	4.6	2.8	80.7
	MIN	0	4	0	8	0	0	35
	MAX	139	115	180	51	12	9	382
	VALIDN	4323						

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1985 THROUGH DEC 1985

MONTH		LIGHTS	HPUMP	HEAT	OUTLETS	VENT	COOLING	TOTAL
JUL:	PCT	40.8	33.1	.6	17.9	2.5	5.2	100.0
	MEAN	64.8	52.6	1.0	28.4	3.9	8.2	158.8
	STDEV	47.7	36.8	3.1	8.0	5.2	.6	93.3
	MIN	0	14	0	5	0	3	52
	MAX	173	127	52	46	12	9	341
	VALIDN	736						
AUG:	PCT	39.8	31.4	1.9	20.7	2.8	3.4	100.0
	MEAN	56.3	44.5	2.7	29.2	4.0	4.8	141.4
	STDEV	39.2	35.0	7.6	9.3	5.2	3.5	89.5
	MIN	0	12	0	13	0	0	47
	MAX	147	121	50	52	12	9	319
	VALIDN	742						
SEP:	PCT	39.3	31.0	4.7	21.1	2.9	1.0	100.0
	MEAN	54.8	43.2	6.6	29.5	4.0	1.5	139.6
	STDEV	37.3	30.5	13.8	9.6	5.2	2.0	86.3
	MIN	2	13	0	17	0	0	51
	MAX	138	112	64	50	12	9	327
	VALIDN	718						
OCT:	PCT	39.8	26.1	10.8	20.5	2.5	.3	100.0
	MEAN	60.4	39.6	16.5	31.1	3.8	.5	151.9
	STDEV	41.6	25.1	22.0	10.5	5.3	1.0	92.9
	MIN	0	13	0	12	0	0	46
	MAX	157	99	95	56	12	5	368
	VALIDN	700						
NOV:	PCT	36.0	23.3	26.8	13.6	.3	.0	100.0
	MEAN	75.2	48.8	56.0	28.5	.6	.0	209.0
	STDEV	43.1	27.4	41.4	11.1	2.5	.2	101.8
	MIN	19	13	0	15	0	0	65
	MAX	171	101	131	57	12	2	415
	VALIDN	485						
DEC:	PCT	33.7	20.3	32.2	12.4	1.3	.0	100.0
	MEAN	80.2	48.2	76.7	29.6	3.1	.0	237.8
	STDEV	43.4	19.2	38.1	11.5	5.0	.0	99.2
	MIN	15	17	7	14	0	0	77
	MAX	180	91	216	59	12	0	468
	VALIDN	530						
TOT:	PCT	38.1	27.4	13.2	17.5	2.0	1.7	100.0
	MEAN	63.9	45.9	22.2	29.4	3.4	2.8	167.7
	STDEV	43.0	30 5	36 0	10.0	5.1	3.6	99.5
	MIN	0	12	0	5	0	0	46
	MAX	180	127	216	59	12	9	468
	VALIDN	3911						

SUMMARY DATA: OFFICE #2

CHARACTERISTICS

Square feet	14,920
Year built	1976
Shell materials	Cedar
Principal use	Office

Appliances	
Space Heat	Electric
Hot water	Electric

LOADS .

Billed consumption	City Light Kwh	Gas Therms
1980	331,560	
1981	297,000	
1982	318,240	Not applicable
1983	310,560	
1984	312,360	
1985	309,840	

Use/ft2 - 6-year average in kwh	21.0
Use/ft2 - 1985	20.8
City Light forecast use/ft2	23.2
Regional forecast use/ft2	24.6

1985 Hourly End-Use Data (kwh/yr)

Electric End Uses	Kwh	Kwh/ sq.ft.	Percent
HVAC	119,454	8.0	46.9
Hot water	0	0	0
Lights	88,396	5.9	34.7
Refrigeration	0	0	0
Elevator	796	.1	.3
Misc equipment	46,189	3.1	18.1
TOTAL	254,836*	17.1*	100.0

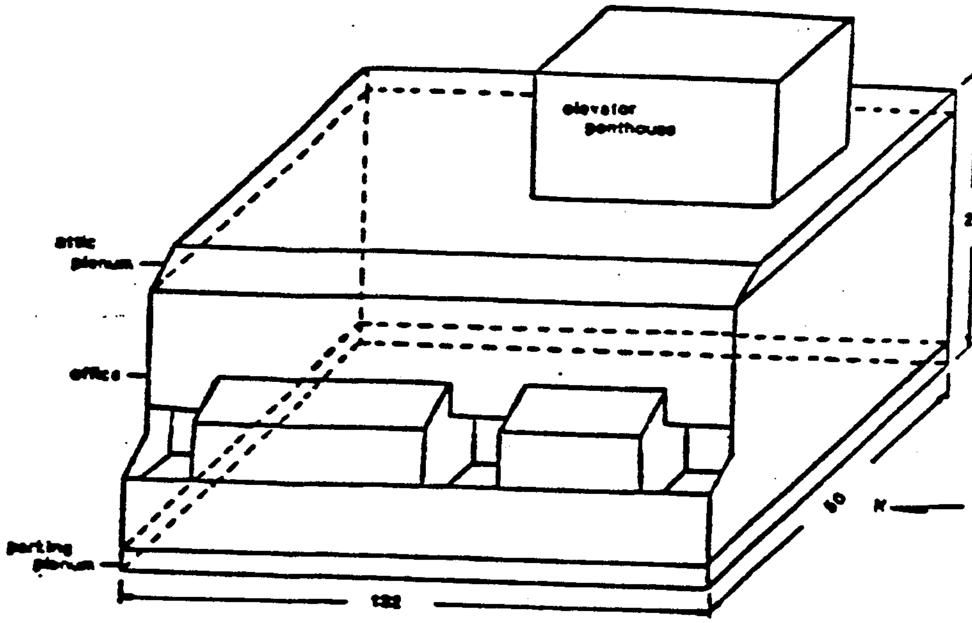
CONSERVATION PACKAGE	Estimated 1984 Costs	Simple Payback	Savings
Damper replacement	$ 2,826	2.3	Elec
Photocell parking lights	217	2.6	Elec
High-pressure sodium (HPS) parking lights	2,412	8.5	Elec
Time clock for lights and HVAC	7,721	10.3	Elec
TOTAL	$13,176	6 yrs elec	

TOTAL ANNUAL ELECTRIC SAVINGS = 75.8 Mwh

Peak 4.5%   Intermediate 10.0%   Off Peak 85.5%

*Equipment measurement exceeded 10 percent accuracy range during months of October-December 1984 and April-December 1985, possibly due to short duration of highly peaking heating load and some missing data.

Office #2



CHEUS office #2 is a two-story building that is typically occupied 58 hours per week, from 8 a.m. to 6 p.m., Monday through Friday, and usually 10 a.m. to 2 p.m. on weekends. The average occupancy is 48 people. Built in 1976, the structure's roof is built up over a plywood deck and walls are wood frame. The total floor area is 20,992 sq.ft., which includes a parking garage. Twelve percent of the gross wall area is glass. The HVAC system consists of electric resistance duct heaters and direct-expansion cooling. Heating and cooling temperatures are manually set at 70° F with a setback of 55° F when the building is unoccupied. Interior lighting is fluorescent. Parking garage lighting is mixed fluorescent and incandescent.

The principal end-use loads in this building are space heat (46.9 percent total energy consumption), interior lighting (34.7 percent), outlets (18.1 percent), and elevator (0.3 percent). The building is an all-electric facility with a 1985 annual electrical consumption of approximately 309,840 kwh and an average 132-kw demand. This facility consumes the equivalent of 71,673 Btu/sq.ft./year.

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

MAY 1983 THROUGH OCT 1983

MONTH		HEATCOOL	LIGHTS	OUTLET	ELEV	TOTAL
MAY:	PCT	41.9	37.9	18.8	1.5	100.0
	MEAN	11.9	10.7	5.3	.4	28.3
	STDEV	12.4	11.1	3.0	.8	22.3
	MIN	0	1	2	0	4
	MAX	55	32	12	4	85
	VALIDN	587				
JUN:	PCT	37.1	41.9	19.0	2.1	100.0
	MEAN	10.6	11.9	5.4	.6	28.5
	STDEV	11.2	11.7	2.9	.9	24.9
	MIN	1	1	3	0	5
	MAX	46	34	12	3	84
	VALIDN	131				
JUL:	PCT	39.8	39.8	18.5	1.9	100.0
	MEAN	10.9	11.0	5.1	.5	27.5
	STDEV	10.9	11.4	2.8	.8	23.6
	MIN	1	1	3	0	5
	MAX	46	34	13	3	88
	VALIDN	742				
AUG:	PCT	40.6	40.4	17.1	1.9	100.0
	MEAN	12.1	12.1	5.1	.6	29.9
	STDEV	12.1	11.9	2.8	.9	25.7
	MIN	1	2	3	0	6
	MAX	49	34	13	4	89
	VALIDN	722				
SEP:	PCT	39.9	41.1	17.4	1.7	100.0
	MEAN	11.3	11.6	4.9	.5	28.2
	STDEV	11.5	11.1	2.7	.8	21.5
	MIN	1	2	2	0	5
	MAX	84	33	12	4	103
	VALIDN	720				
OCT:	PCT	47.1	36.6	15.0	1.3	100.0
	MEAN	16.0	12.4	5.1	.4	33.9
	STDEV	13.4	10.7	2.8	.7	18.5
	MIN	1	1	2	0	6
	MAX	80	33	12	4	98
	VALIDN	744				
TOT:	PCT	41.9	39.2	17.3	1.7	100.0
	MEAN	12.4	11.6	5.1	.5	29.6
	STDEV	12.2	11.3	2.8	.8	22.6
	MIN	0	1	2	0	4
	MAX	84	34	13	4	103
	VALIDN	3646				

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1983 THROUGH DEC 1983

MONTH		HEATCOOL	LIGHTS	OUTLET	ELEV	TOTAL
JUL:	PCT	39.8	39.8	18.5	1.9	100.0
	MEAN	10.9	11.0	5.1	.5	27.5
	STDEV	10.9	11.4	2.8	.8	23.6
	MIN	1	1	3	0	5
	MAX	46	34	13	3	88
	VALIDN	742				
AUG:	PCT	40.6	40.4	17.1	1.9	100.0
	MEAN	12.1	12.1	5.1	.6	29.9
	STDEV	12.1	11.9	2.8	.9	25.7
	MIN	1	2	3	0	6
	MAX	49	34	13	4	89
	VALIDN	722				
SEP:	PCT	39.9	41.1	17.4	1.7	100.0
	MEAN	11.3	11.6	4.9	.5	28.2
	STDEV	11.5	11.1	2.7	.8	21.5
	MIN	1	2	2	0	5
	MAX	84	33	12	4	103
	VALIDN	720				
OCT:	PCT	47.1	36.6	15.0	1.3	100.0
	MEAN	16.0	12.4	5.1	.4	33.9
	STDEV	13.4	10.7	2.8	.7	18.5
	MIN	1	1	2	0	6
	MAX	80	33	12	4	98
	VALIDN	744				
NOV:	PCT	59.6	27.4	12.0	1.1	100.0
	MEAN	25.4	11.7	5.1	.5	42.6
	STDEV	15.6	11.0	2.8	.8	16.0
	MIN	1	2	3	0	9
	MAX	87	35	13	4	99
	VALIDN	720				
DEC:	PCT	71.8	19.4	8.1	.7	100.0
	MEAN	46.3	12.5	5.2	.4	64.5
	STDEV	25.0	10.8	3.0	.8	25.9
	MIN	3	3	3	0	14
	MAX	117	36	13	4	148
	VALIDN	743				
TOT:	PCT	53.9	31.4	13.5	1.3	100.0
	MEAN	20.4	11.9	5.1	.5	37.8
	STDEV	20.1	11.2	2.8	.8	25.7
	MIN	1	1	2	0	5
	MAX	117	36	13	4	148
	VALIDN	4391				

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1984 THROUGH JUN 1984

MONTH		HEATCOOL	LIGHTS	OUTLET	ELEV	TOTAL
JAN:	PCT	61.9	26.1	10.9	1.0	100.0
	MEAN	30.9	13.0	5.5	.5	49.9
	STDEV	21.6	11.1	3.1	.8	23.5
	MIN	1	3	2	0	8
	MAX	98	34	13	5	131
	VALIDN	744				
FEB:	PCT	59.5	27.4	11.9	1.2	100.0
	MEAN	27.2	12.5	5.4	.5	45.7
	STDEV	18.1	10.9	3.1	.9	20.1
	MIN	1	3	2	0	11
	MAX	100	34	13	5	107
	VALIDN	695				
MAR:	PCT	48.0	35.6	15.0	1.4	100.0
	MEAN	17.6	13.0	5.5	.5	36.7
	STDEV	15.3	10.9	2.8	.8	18.6
	MIN	1	3	3	0	7
	MAX	79	35	12	4	89
	VALIDN	743				
APR:	PCT	46.3	36.5	15.8	1.4	100.0
	MEAN	15.6	12.3	5.3	.5	33.6
	STDEV	14.1	11.2	3.0	.8	19.5
	MIN	1	3	3	0	7
	MAX	75	34	13	4	98
	VALIDN	718				
MAY:	PCT	37.6	42.7	18.0	1.7	100.0
	MEAN	11.2	12.7	5.4	.5	29.8
	STDEV	9.4	10.9	2.9	.8	18.3
	MIN	1	2	3	0	6
	MAX	51	34	13	5	84
	VALIDN	743				
JUN:	PCT	36.2	44.0	18.2	1.6	100.0
	MEAN	10.1	12.2	5.1	.4	27.8
	STDEV	8.4	10.4	2.6	.8	19.4
	MIN	1	2	3	0	6
	MAX	40	33	11	4	80
	VALIDN	719				
TOT:	PCT	50.3	34.0	14.4	1.3	100.0
	MEAN	18.7	12.6	5.4	.5	37.2
	STDEV	17.1	10.9	2.9	.8	21.5
	MIN	1	2	2	0	6
	MAX	100	35	13	5	131
	VALIDN	4362				

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1984 THROUGH DEC 1984

MONTH		HEATCOOL	LIGHTS	OUTLET	ELEV	TOTAL
JUL:	PCT	41.0	40.6	16.8	1.6	100.0
	MEAN	11.7	11.6	4.8	.5	28.5
	STDEV	11.6	10.7	2.3	.8	23.3
	MIN	1	2	3	0	6
	MAX	48	32	10	5	90
	VALIDN	744				
AUG:	PCT	35.9	44.4	17.7	2.0	100.0
	MEAN	9.8	12.1	4.8	.5	27.3
	STDEV	11.2	10.6	2.1	.8	23.3
	MIN	1	2	3	0	6
	MAX	45	33	10	3	84
	VALIDN	741				
SEP:	PCT	31.8	46.2	19.8	2.1	100.0
	MEAN	7.8	11.4	4.9	.5	24.6
	STDEV	8.3	10.2	2.3	.8	19.4
	MIN	1	2	3	0	6
	MAX	70	33	12	4	77
	VALIDN	720				
OCT:	PCT	47.1	34.7	16.6	1.6	100.0
	MEAN	14.5	10.7	5.1	.5	30.8
	STDEV	19.3	10.9	2.5	.8	26.3
	MIN	1	2	3	0	6
	MAX	114	31	11	4	124
	VALIDN	744				
NOV:	PCT	57.8	27.2	13.8	1.3	100.0
	MEAN	21.3	10.0	5.1	.5	36.8
	STDEV	23.2	10.7	2.6	.8	30.6
	MIN	1	2	3	0	6
	MAX	118	33	11	3	142
	VALIDN	719				
DEC:	PCT	71.3	17.5	10.4	.7	100.0
	MEAN	36.3	8.9	5.3	.4	50.9
	STDEV	23.7	10.2	2.7	.7	29.7
	MIN	1	1	3	0	6
	MAX	124	32	14	4	139
	VALIDN	720				
TOT:	PCT	50.9	32.6	15.1	1.4	100.0
	MEAN	16.8	10.8	5.0	.5	33.1
	STDEV	19.8	10.6	2.4	.8	27.1
	MIN	1	1	3	0	6
	MAX	124	33	14	5	142
	VALIDN	4388				

AVERAGE HOURLY KWH FOR THE COMMERCIAL HOURLY END-USE STUDY BY MONTH

JAN 1985 THROUGH JUN 1985

MONTH		HEATCOOL	LIGHTS	OUTLET	ELEV	TOTAL
JAN:	PCT	63.2	23.3	12.4	1.2	100.0
	MEAN	28.8	10.6	5.6	.5	45.5
	STDEV	20.5	11.2	3.0	.9	25.6
	MIN	1	2	3	0	6
	MAX	106	34	13	4	133
	VALIDN	537				
FEB:	PCT	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0
	VALIDN	0				
MAR:	PCT	54.7	29.9	14.0	1.4	100.0
	MEAN	19.2	10.5	4.9	.5	35.1
	STDEV	20.1	11.4	2.3	.8	23.1
	MIN	1	2	3	0	6
	MAX	87	32	10	3	94
	VALIDN	127				
APR:	PCT	39.0	39.7	19.5	1.8	100.0
	MEAN	10.5	10.7	5.3	.5	26.9
	STDEV	11.5	11.2	2.3	.8	19.1
	MIN	0	1	3	0	4
	MAX	73	32	11	4	99
	VALIDN	298				
MAY:	PCT	34.9	41.7	21.5	1.9	100.0
	MEAN	8.3	9.9	5.1	.5	23.8
	STDEV	9.6	11.6	2.3	.8	20.9
	MIN	1	1	3	0	5
	MAX	58	33	12	4	90
	VALIDN	743				
JUN:	PCT	31.3	44.9	21.9	1.9	100.0
	MEAN	6.9	9.9	4.8	.4	22.0
	STDEV	8.2	10.7	2.2	.7	20.2
	MIN	1	1	3	0	5
	MAX	44	32	10	3	72
	VALIDN	719				
TOT:	PCT	45.6	35.0	17.7	1.6	100.0
	MEAN	13.3	10.2	5.1	.5	29.0
	STDEV	15.9	11.2	2.4	.8	23.6
	MIN	0	1	3	0	4
	MAX	106	34	13	4	133
	VALIDN	2424				

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1985 THROUGH DEC 1985

MONTH		HEATCOOL	LIGHTS	OUTLET	ELEV	TOTAL
JUL:	PCT	35.9	40.9	21.5	1.7	100.0
	MEAN	8.5	9.7	5.1	.4	23.7
	STDEV	10.2	11.0	2.0	.7	22.3
	MIN	1	1	3	0	5
	MAX	41	31	10	4	78
	VALIDN	641				
AUG:	PCT	28.7	45.3	24.1	1.9	100.0
	MEAN	6.2	9.7	5.2	.4	21.4
	STDEV	7.6	10.6	2.0	.7	19.8
	MIN	1	1	3	0	5
	MAX	35	30	11	3	69
	VALIDN	693				
SEP:	PCT	27.7	45.2	25.1	2.0	100.0
	MEAN	5.8	9.4	5.2	.4	20.7
	STDEV	5.7	10.7	2.0	.7	17.3
	MIN	1	1	3	0	5
	MAX	41	31	11	4	72
	VALIDN	693				
OCT:	PCT	37.1	39.7	21.2	2.0	100.0
	MEAN	9.4	10.0	5.4	.5	25.3
	STDEV	10.8	10.7	2.4	.8	18.7
	MIN	1	1	3	0	5
	MAX	61	30	11	3	83
	VALIDN	738				
NOV:	PCT	62.1	23.3	13.7	.9	100.0
	MEAN	25.1	9.4	5.5	.4	40.4
	STDEV	18.5	10.0	2.5	.6	20.3
	MIN	1	1	3	0	5
	MAX	80	32	14	3	86
	VALIDN	715				
DEC:	PCT	59.2	24.5	14.9	1.0	100.0
	MEAN	23.7	9.8	6.0	.4	40.0
	STDEV	19.8	10.7	2.8	.7	22.0
	MIN	1	1	3	0	6
	MAX	85	32	13	3	92
	VALIDN	501				
TOT:	PCT	45.0	34.4	19.1	1.5	100.0
	MEAN	12.7	9.7	5.4	.4	28.1
	STDEV	15.1	10.6	2.3	.7	21.6
	MIN	1	1	3	0	5
	MAX	85	32	14	4	92
	VALIDN	3981				

SUMMARY DATA: GROCERY #1

CHARACTERISTICS

Square feet	24,800
Year built	1969
Shell materials	Concrete
Principal use	Grocery

Appliances	
Space Heat	Electric heat pump
Hot water	Electric
Major equipment	Refrigeration

LOADS

Billed consumption	City Light Kwh	Gas Therms
1980	1,422,720	
1981	1,450,800	
1982	1,506,720	
1983	1,438,800	
1984	1,539,360	
1985	1,558,560	

Use/ft2 - 6-year average in kwh	59.9
Use/ft2 - 1985	62.9
City Light forecast use/ft2	38.8
Regional forecast use/ft2	56.8

1985 Hourly End-Use Data (kwh/yr)

Electric End Uses	Kwh	Kwh/ sq.ft.	Percent
HVAC	424,130	17.1	28.1
Hot water	0	0	0
Lights	475,230	19.2	31.4
Refrigeration	546,700	22.1	36.2
Elevator	0	0	0
Misc equipment	65,700	2.6	4.3
TOTAL	1,511,830*	61.0*	100.0

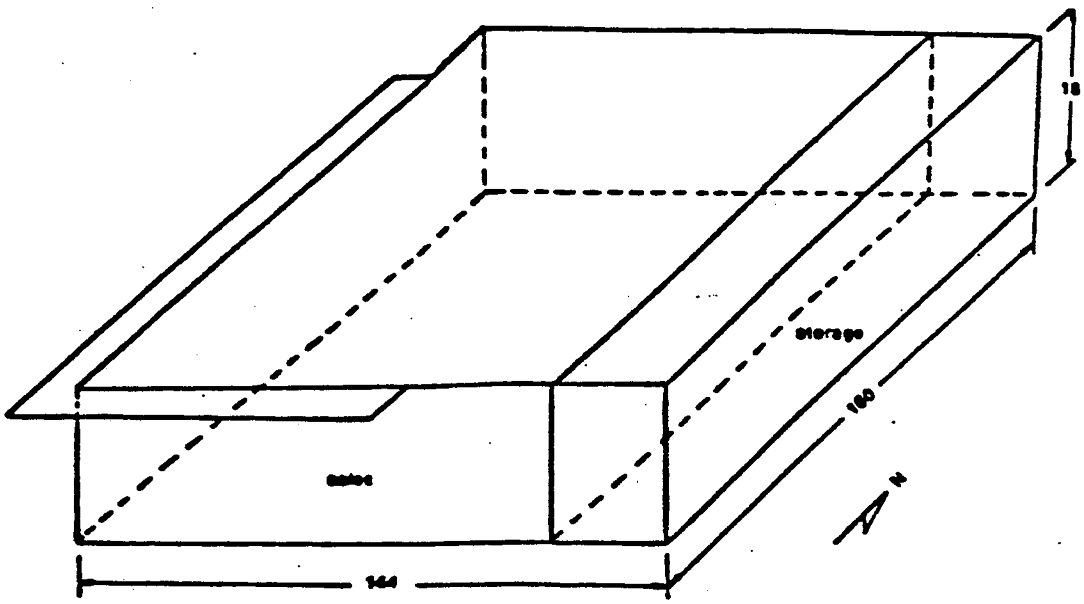
CONSERVATION PACKAGE	Estimated 1984 Costs	Simple Payback	Savings
Outside air shutoff	$ 455	0.2	Elec
Bank switching	1,749	3.4	Elec
Case curtains	3,557	2.4	Elec
Heat recovery	19,166	8.2	Elec
Ceiling to R-18	18,961	26.1	Elec
TOTAL	$43,888	6 yrs elec	

TOTAL ANNUAL ELECTRIC SAVINGS = 228.6 Mwh

Peak 3.4% Intermediate 21.2% Off Peak 75.4%

*Within the accuracy range of the monitoring equipment.

Grocery #1



CHEUS grocery #1 is a typical single-story, large grocery store that is open for business 90 hours a week. The average number of customers per hour is 28. Built in 1969, the building was constructed on a concrete slab, has walls of concrete, and the roof is built up over a plywood deck. The total floor area is 24,800 sq.ft. Seventy-one percent of this space is sales area, 19 percent storage, and 10 percent office, etc. Seven percent of the gross wall area is glass. In the sales area the HVAC system consists of four electric heat pump units with cooling units. The office and lounge are served by unit heaters and baseboard units. Interior lighting is fluorescent with some incandescent spots. Exterior lighting is all fluorescent.

The principal end-use loads in this building are refrigeration equipment such as walk-in coolers, walk-in freezers, display cooler cases, and display freezer cases (36.2 percent of total energy consumption); interior lighting (31.4 percent); space heat (16.7 percent); ventilation (11.3 percent); and processing equipment (4.3 percent). The store is an all-electric facility. The 1985 annual electrical consumption was 1,558,560 kwh, with an average 230-kw demand. This facility consumes an equivalent of 204,379 Btu/sq.ft./year.

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

MAY 1983 THROUGH OCT 1983

MONTH		REFRIG	LIGHTS	PROCESS	VENT	XLIGHTS	TOTAL
MAY:	PCT	56.9	29.0	4.8	1.1	7.8	100.0
	MEAN	89.4	45.5	7.5	1.7	12.2	157.2
	STDEV	3.6	.6	2.0	.5	1.5	4.7
	MIN	82	44	2	1	9	146
	MAX	97	46	11	3	14	169
	VALIDN	161					
JUN:	PCT	57.3	29.3	3.8	1.3	8.3	100.0
	MEAN	90.0	46.0	6.0	2.0	13.0	157.0
	STDEV	I	I	I	I	I	I
	MIN	90	46	6	2	13	157
	MAX	90	46	6	2	13	157
	VALIDN	1					
JUL:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
AUG:	PCT	62.6	26.9	5.9	1.0	3.6	100.0
	MEAN	102.2	43.8	9.7	1.6	5.8	163.1
	STDEV	3.4	.7	2.1	.5	5.7	5.9
	MIN	93	39	4	1	0	149
	MAX	108	45	13	2	12	175
	VALIDN	151					
SEP:	PCT	62.4	27.4	5.5	.7	4.0	100.0
	MEAN	100.5	44.2	8.8	1.2	6.4	161.1
	STDEV	3.7	.5	2.0	.4	5.8	5.8
	MIN	89	43	3	0	0	146
	MAX	110	46	13	2	12	175
	VALIDN	720					
OCT:	PCT	61.9	27.8	5.2	.6	4.3	100.0
	MEAN	100.2	45.0	8.4	1.0	7.0	161.8
	STDEV	3.2	.3	1.8	3	5.8	5.4
	MIN	90	44	4	0	0	147
	MAX	106	46	11	2	13	173
	VALIDN	175					
TOT:	PCT	61.6	27.6	5.4	.8	4.5	100.0
	MEAN	99.2	44.4	8.7	1.3	7.2	160.9
	STDEV	5.3	.8	2.0	.5	5.8	5.8
	MIN	82	39	2	0	0	146
	MAX	110	46	13	3	14	175
	VALIDN	1208					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1983 THROUGH DEC 1983

MONTH		REFRIG	LIGHTS	PROCESS	VENT	XLIGHTS	TOTAL
JUL:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
AUG:	PCT	62.6	26.9	5.9	1.0	3.6	100.0
	MEAN	102.2	43.8	9.7	1.6	5.8	163.1
	STDEV	3.4	.7	2.1	.5	5.7	5.9
	MIN	93	39	4	1	0	149
	MAX	108	45	13	2	12	175
	VALIDN	151					
SEP:	PCT	62.4	27.4	5.5	.7	4.0	100.0
	MEAN	100.5	44.2	8.8	1.2	6.4	161.1
	STDEV	3.7	.5	2.0	.4	5.8	5.8
	MIN	89	43	3	0	0	146
	MAX	110	46	13	2	12	175
	VALIDN	720					
OCT:	PCT	61.9	27.8	5.2	.6	4.3	100.0
	MEAN	100.2	45.0	8.4	1.0	7.0	161.8
	STDEV	3.2	.3	1.8	.3	5.8	5.4
	MIN	90	44	4	0	0	147
	MAX	106	46	11	2	13	173
	VALIDN	175					
NOV:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
DEC:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
TOT:	PCT	62.4	27.4	5.5	.7	4.0	100.0
	MEAN	100.7	44.3	8.9	1.2	6.4	161.5
	STDEV	3.7	.6	2.0	.5	5.8	5.8
	MIN	89	39	3	0	0	146
	MAX	110	46	13	2	13	175
	VALIDN	1046					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1984 THROUGH JUN 1984

MONTH		REFRIG	LIGHTS	PROCESS	VENT	XLIGHTS	TOTAL
JAN:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
FEB:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
MAR:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
APR:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
MAY:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
JUN:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
TOT:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1984 THROUGH DEC 1984

MONTH		REFRIG	LIGHTS	PROCESS	VENT	XLIGHTS	TOTAL
JUL:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
AUG:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
SEP:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
OCT:	PCT	.0	.0	.0	.0	.0	.0
	MEAN	.0	.0	.0	.0	.0	.0
	STDEV	.0	.0	.0	.0	.0	.0
	MIN	999999	999999	999999	999999	999999	999999
	MAX	0	0	0	0	0	0
	VALIDN	0					
NOV:	PCT	60.4	25.5	5.2	.6	8.6	100.0
	MEAN	97.7	41.2	8.5	1.0	13.9	161.8
	STDEV	9.0	3.1	1.4	.0	.9	12.9
	MIN	23	12	4	1	6	51
	MAX	106	43	11	1	14	173
	VALIDN	607					
DEC:	PCT	60.4	25.5	5.0	.5	8.7	100.0
	MEAN	96.3	40.7	8.0	.8	13.8	159.4
	STDEV	3.5	1.0	1.6	.4	.4	4.7
	MIN	88	38	2	0	13	147
	MAX	107	43	12	1	15	174
	VALIDN	742					
TOT:	PCT	60.4	25.5	5.1	.6	8.6	100.0
	MEAN	96.9	41.0	8.2	.9	13.8	160.5
	STDEV	6.6	2.2	1.5	.3	.7	9.4
	MIN	23	12	2	0	6	51
	MAX	107	43	12	1	15	174
	VALIDN	1349					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1985 THROUGH JUN 1985

MONTH		REFRIG	LIGHTS	PROCESS	VENT	XLIGHTS	TOTAL
JAN:	PCT	60.6	25.5	5.1	.4	8.4	100.0
	MEAN	96.8	40.7	8.1	.7	13.5	159.8
	STDEV	4.2	1.1	1.9	.5	.5	5.5
	MIN	86	39	2	0	13	147
	MAX	106	42	11	1	14	172
	VALIDN	450					
FEB:	PCT	60.4	25.1	5.4	.7	8.3	100.0
	MEAN	99.6	41.4	8.9	1.1	13.7	165.1
	STDEV	3.4	1.1	1.9	.3	.4	4.7
	MIN	90	39	3	1	13	152
	MAX	107	43	12	2	14	174
	VALIDN	326					
MAR:	PCT	62.4	25.9	5.5	.7	5.2	100.0
	MEAN	101.4	42.1	8.9	1.2	8.5	162.4
	STDEV	4.1	1.4	1.9	.4	6.4	5.7
	MIN	90	31	3	1	0	145
	MAX	114	44	12	2	14	179
	VALIDN	743					
APR:	PCT	62.8	25.3	5.3	.8	5.8	100.0
	MEAN	104.1	41.9	8.7	1.3	9.6	165.8
	STDEV	3.7	1.1	1.9	.5	6.0	6.8
	MIN	92	39	3	0	0	141
	MAX	116	44	12	2	14	183
	VALIDN	718					
MAY:	PCT	61.8	24.6	5.3	1.0	7.3	100.0
	MEAN	104.3	41.4	8.9	1.7	12.3	168.7
	STDEV	4.1	1.2	1.8	.5	3.6	6.1
	MIN	91	30	4	1	0	146
	MAX	117	44	12	2	14	183
	VALIDN	743					
JUN:	PCT	64.2	24.7	5.5	1.2	4.4	100.0
	MEAN	106.8	41.2	9.2	1.9	7.3	166.5
	STDEV	3.9	1.1	1.8	.3	6.6	7.3
	MIN	94	39	4	1	0	146
	MAX	118	43	12	2	14	186
	VALIDN	719					
TOT:	PCT	62.3	25.2	5.4	.8	6.2	100.0
	MEAN	102.9	41.5	8.8	1.4	10.3	165.0
	STDEV	5.0	1.3	1.9	.6	5.6	6.8
	MIN	86	30	2	0	0	141
	MAX	118	44	12	2	14	186
	VALIDN	3699					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1985 THROUGH DEC 1985

MONTH		REFRIG	LIGHTS	PROCESS	VENT	XLIGHTS	TOTAL
JUL:	PCT	62.8	23.4	5.7	.9	7.1	100.0
	MEAN	111.3	41.5	10.1	1.7	12.7	177.4
	STDEV	7.4	2.3	2.2	.5	1.8	11.2
	MIN	3	1	0	0	0	4
	MAX	124	44	14	2	14	193
	VALIDN	743					
AUG:	PCT	65.7	23.6	5.9	1.2	3.5	100.0
	MEAN	109.8	39.5	9.8	2.0	5.8	167.1
	STDEV	4.4	2.2	2.0	.3	6.3	7.4
	MIN	90	35	4	1	0	140
	MAX	120	43	14	3	14	187
	VALIDN	742					
SEP:	PCT	65.0	23.9	5.6	1.1	4.4	100.0
	MEAN	104.1	38.2	8.9	1.8	7.1	160.2
	STDEV	3.8	1.0	1.7	.4	6.6	6.2
	MIN	94	35	4	1	0	144
	MAX	115	40	13	3	14	178
	VALIDN	717					
OCT:	PCT	65.1	23.8	5.6	.8	4.6	100.0
	MEAN	104.6	38.3	8.9	1.3	7.5	160.6
	STDEV	3.5	1.0	1.7	.5	6.6	6.1
	MIN	96	36	4	1	0	147
	MAX	114	40	12	2	14	174
	VALIDN	186					
NOV:	PCT	62.6	26.1	5.2	.2	5.7	100.0
	MEAN	91.0	37.9	7.6	.3	8.2	145.2
	STDEV	5.6	1.2	1.8	.5	6.0	7.9
	MIN	74	35	3	0	0	119
	MAX	105	40	10	1	14	165
	VALIDN	509					
DEC:	PCT	65.0	23.1	5.2	.3	6.3	100.0
	MEAN	89.9	31.9	7.2	.4	8.7	138.2
	STDEV	5.1	6.9	1.4	.5	6.1	10.0
	MIN	76	2	4	0	0	108
	MAX	103	42	10	1	14	160
	VALIDN	521					
TOT:	PCT	64.3	23.9	5.6	.9	5.3	100.0
	MEAN	102.8	38.2	8.9	1.4	8.5	159.9
	STDEV	10.1	4.3	2.2	.8	6.1	16.0
	MIN	3	1	0	0	0	4
	MAX	124	44	14	3	14	193
	VALIDN	3418					

SUMMARY DATA: GROCERY #2

CHARACTERISTICS

Square feet	16,843
Year built	1960
Shell materials	Concrete
Principal use	Grocery

Appliances	
Space Heat	Gas
Hot water	Gas
Major equipment	Refrigeration

LOADS

Billed consumption	City Light Kwh	Gas Therms
1980	1,453,320	5,791.0
1981	1,457,540	8,080.9
1982	1,538,460	8,680.8
1983	1,535,760	5,965.7
1984	1,494,900	Not available
1985	1,412,640	Not available

Use/ft2 - 6-year average in kwh	88.1	12.4
Use/ft2 - 1985	83.9	
City Light forecast use/ft2	35.0	
Regional forecast use/ft2	56.8	

1985 Hourly End-Use Data (kwh/yr)

Electric End Uses	Kwh	Kwh/ sq.ft.	Percent
HVAC	10,950	0.7	0.8
Hot water	0	0	0
Lights	429,240	25.5	30.5
Refrigeration	893,520	53.1	63.2
Elevator	0	0	0
Misc equipment	77,380	4.6	5.5
TOTAL	1,411,090*	83.9*	100.0

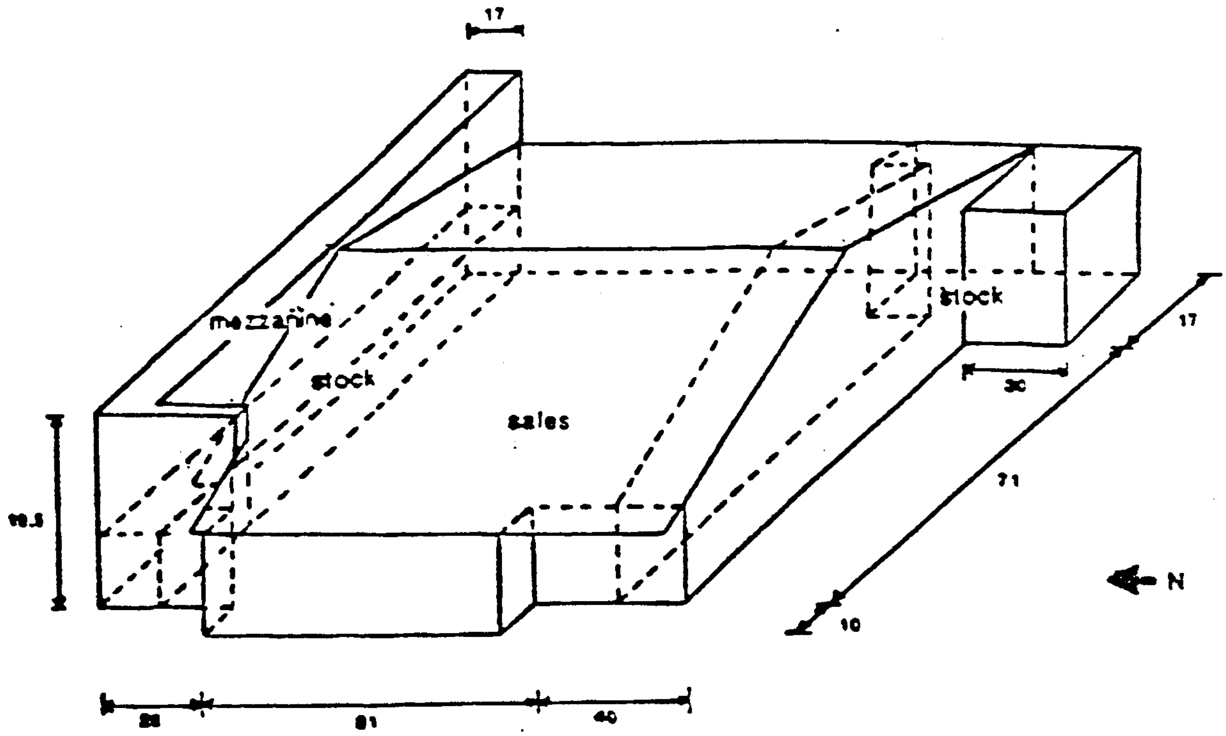
CONSERVATION PACKAGE	Estimated 1984 Costs	Simple Payback	Savings
Light level reductions	$1,725	-2.2	Elec
Walk-in cooler light controls	169	1.4	Elec
Case curtains	3,242	1.4	Elec
Interior light controls	2,919	3.0	Elec
Night setback	676	1.0	Gas
TOTAL	$8,731	4 yrs elec 2 yrs gas	

TOTAL ANNUAL ELECTRIC SAVINGS = 255.5 Mwh

Peak 2.1% Intermediate 9.9% Off Peak 87.9%

*Within the accuracy range of the monitoring equipment.

Grocery #2



CHEUS grocery #2 is a typical single-story, large grocery store that is open for business 103 hours a week. The average number of customers per hour is 48. Built in 1960 and modified in 1974, the building was constructed on a concrete slab, has walls of concrete block, and a built-up roof over a plywood deck. The total floor area of the building is 16,843 sq.ft. Fifty-three percent of this space is sales area, 18 percent refrigeration, 13 percent stockroom, and 12 percent office and lounge. Five percent of the gross wall area is glass. There is no cooling system in this building. A mix of gas-fired heaters, unit ventilators, and electric resistance heaters heats the building. Interior lighting is energy-efficient, surface-mounted fluorescent fixtures. Exterior lighting is mixed mercury vapor and fluorescent.

The principal end-use loads in this building are refrigeration equipment, such as walk-in coolers, walk-in freezers, display cooler cases, and display freezer cases (40.6 percent of total energy consumption); interior lighting (24.6 percent); exterior lighting (5.9 percent); miscellaneous equipment such as registers and meat and vegetable preparation equipment (28.1 percent); and ventilation (0.8 percent). Although natural gas is used for space heating and domestic hot water, all other end uses are electrical. The 1985 annual electric consumption was 1,412,640 kwh with an average 200-kw demand. The average natural gas consumption is approximately 7,130 therms. This facility consumes the equivalent of 343,000 Btu/sq.ft./year.

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

MAY 1983 THROUGH OCT 1983

MONTH		REFRIG	LIGHTS	HPUMP	VENT	PROCESS	TOTAL
MAY:	PCT	40.2	37.3	5.7	13.0	3.8	100.0
	MEAN	63.4	58.7	8.9	20.5	5.9	157.5
	STDEV	4.2	24.1	10.8	1.6	2.0	27.7
	MIN	53	0	0	18	3	81
	MAX	80	78	36	26	15	215
	VALIDN	744					
JUN:	PCT	41.0	39.7	2.4	13.0	3.8	100.0
	MEAN	64.9	62.9	3.8	20.6	6.0	158.2
	STDEV	4.1	21.0	6.2	1.1	1.9	21.5
	MIN	53	1	0	19	3	88
	MAX	75	79	21	24	14	198
	VALIDN	712					
JUL:	PCT	41.5	39.2	2.2	13.2	3.9	100.0
	MEAN	65.9	62.3	3.5	21.0	6.1	158.9
	STDEV	4.0	21.9	6.0	1.4	2.1	22.8
	MIN	52	9	0	18	3	91
	MAX	77	79	21	27	14	192
	VALIDN	303					
AUG:	PCT	41.8	39.5	1.0	13.5	4.3	100.0
	MEAN	66.4	62.7	1.5	21.4	6.7	158.7
	STDEV	3.9	20.9	3.2	1.5	2.2	23.8
	MIN	56	7	0	19	4	93
	MAX	79	78	21	27	15	193
	VALIDN	219					
SEP:	PCT	39.5	37.9	5.8	12.8	3.9	100.0
	MEAN	62.6	60.1	9.2	20.2	6.2	158.5
	STDEV	3.6	18.6	8.7	1.1	2.5	21.1
	MIN	53	0	0	18	3	86
	MAX	76	77	36	26	13	210
	VALIDN	248					
OCT:	PCT	37.1	36.6	10.7	12.1	3.6	100.0
	MEAN	63.0	62.2	18.1	20.5	6.1	169.9
	STDEV	4.7	19.8	11.0	1.1	2.1	21.9
	MIN	47	0	0	18	3	96
	MAX	75	79	51	24	13	216
	VALIDN	696					
TOT:	PCT	39.8	38.1	5.5	12.8	3.8	100.0
	MEAN	64.1	61.4	8.8	20.6	6.1	161.0
	STDEV	4.4	21.5	10.6	1.3	2.1	24.1
	MIN	47	0	0	18	3	81
	MAX	80	79	51	27	15	216
	VALIDN	2922					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1983 THROUGH DEC 1983

MONTH		REFRIG	LIGHTS	HPUMP	VENT	PROCESS	TOTAL
JUL:	PCT	41.5	39.2	2.2	13.2	3.9	100.0
	MEAN	65.9	62.3	3.5	21.0	6.1	158.9
	STDEV	4.0	21.9	6.0	1.4	2.1	22.8
	MIN	52	9	0	18	3	91
	MAX	77	79	21	27	14	192
	VALIDN	303					
AUG:	PCT	41.8	39.5	1.0	13.5	4.3	100.0
	MEAN	66.4	62.7	1.5	21.4	6.7	158.7
	STDEV	3.9	20.9	3.2	1.5	2.2	23.8
	MIN	56	7	0	19	4	93
	MAX	79	78	21	27	15	193
	VALIDN	219					
SEP:	PCT	39.5	37.9	5.8	12.8	3.9	100.0
	MEAN	62.6	60.1	9.2	20.2	6.2	158.5
	STDEV	3.6	18.6	8.7	1.1	2.5	21.1
	MIN	53	0	0	18	3	86
	MAX	76	77	36	26	13	210
	VALIDN	248					
OCT:	PCT	37.1	36.6	10.7	12.1	3.6	100.0
	MEAN	63.0	62.2	18.1	20.5	6.1	169.9
	STDEV	4.7	19.8	11.0	1.1	2.1	21.9
	MIN	47	0	0	18	3	96
	MAX	75	79	51	24	13	216
	VALIDN	696					
NOV:	PCT	34.4	31.5	19.4	11.0	3.6	100.0
	MEAN	61.7	56.6	34.8	19.8	6.5	179.4
	STDEV	5.7	21.8	14.2	1.2	2.6	25.0
	MIN	44	1	12	17	2	105
	MAX	73	78	54	23	16	225
	VALIDN	410					
DEC:	PCT	30.6	28.6	26.8	10.2	3.7	100.0
	MEAN	58.0	54.3	50.9	19.4	7.0	189.6
	STDEV	4.8	23.2	4.6	1.1	3.4	28.1
	MIN	45	0	39	18	2	117
	MAX	73	74	65	23	16	230
	VALIDN	740					
TOT:	PCT	35.7	33.9	15.0	11.6	3.7	100.0
	MEAN	62.0	58.9	26.1	20.2	6.5	173.7
	STDEV	5.5	21.6	20.5	1.4	2.7	27.3
	MIN	44	0	0	17	2	86
	MAX	79	79	65	27	16	230
	VALIDN	2616					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1984 THROUGH JUN 1984

MONTH		REFRIG	LIGHTS	HPUMP	VENT	PROCESS	TOTAL
JAN:	PCT	30.5	27.3	29.0	9.8	3.4	100.0
	MEAN	61.1	54.6	58.1	19.7	6.8	200.3
	STDEV	4.6	22.5	7.4	1.1	3.2	27.3
	MIN	46	1	40	18	2	124
	MAX	73	74	66	23	16	235
	VALIDN	734					
FEB:	PCT	32.1	29.6	24.5	10.1	3.6	100.0
	MEAN	62.4	57.6	47.6	19.7	7.1	194.2
	STDEV	4.1	20.5	7.8	1.2	3.0	25.9
	MIN	50	1	26	17	3	100
	MAX	72	74	66	23	16	233
	VALIDN	613					
MAR:	PCT	33.8	30.2	21.2	10.8	3.9	100.0
	MEAN	62.7	55.9	39.3	20.0	7.3	185.4
	STDEV	3.9	20.8	4.9	1.2	3.0	24.9
	MIN	50	0	25	17	3	112
	MAX	71	72	43	24	16	212
	VALIDN	307					
APR:	PCT	35.6	31.5	17.5	11.4	4.0	100.0
	MEAN	62.7	55.5	30.8	20.0	7.1	176.1
	STDEV	4.0	18.7	7.1	1.4	2.7	22.4
	MIN	50	0	17	15	3	103
	MAX	71	71	45	24	14	211
	VALIDN	190					
MAY:	PCT	38.0	35.0	10.7	12.2	4.1	100.0
	MEAN	64.1	59.1	18.1	20.5	7.0	168.8
	STDEV	4.5	17.5	7.9	1.5	2.5	21.6
	MIN	51	1	1	18	3	96
	MAX	75	74	36	26	16	204
	VALIDN	294					
JUN:	PCT	41.0	36.1	5.4	12.9	4.6	100.0
	MEAN	65.7	57.8	8.7	20.7	7.4	160.4
	STDEV	4.8	19.3	4.7	1.5	2.7	23.0
	MIN	52	0	0	18	3	91
	MAX	76	75	14	26	16	189
	VALIDN	591					
TOT:	PCT	34.3	30.9	20.0	10.9	3.9	100.0
	MEAN	63.0	56.7	36.7	20.1	7.1	183.5
	STDEV	4.7	20.5	20.2	1.3	2.9	29.4
	MIN	46	0	0	15	2	91
	MAX	76	75	66	26	16	235
	VALIDN	2729					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1984 THROUGH DEC 1984

MONTH		REFRIG	LIGHTS	HPUMP	VENT	PROCESS	TOTAL
JUL:	PCT	42.7	33.1	5.9	13.4	4.9	100.0
	MEAN	68.2	52.9	9.4	21.4	7.9	159.8
	STDEV	4.2	8.1	5.5	1.3	2.5	13.6
	MIN	55	14	1	19	4	106
	MAX	77	65	17	25	14	181
	VALIDN	388					
AUG:	PCT	40.9	34.6	7.3	12.7	4.5	100.0
	MEAN	67.0	56.5	11.9	20.7	7.4	163.6
	STDEV	4.4	20.3	3.2	1.2	2.6	25.6
	MIN	52	0	6	18	4	92
	MAX	78	74	20	24	16	192
	VALIDN	680					
SEP:	PCT	41.7	35.0	5.3	13.4	4.6	100.0
	MEAN	64.4	54.0	8.2	20.7	7.1	154.3
	STDEV	4.9	19.0	4.2	1.5	2.6	23.0
	MIN	42	0	0	7	3	85
	MAX	74	74	23	25	16	184
	VALIDN	509					
OCT:	PCT	36.7	31.0	15.6	11.6	5.1	100.0
	MEAN	64.3	54.3	27.3	20.3	8.9	175.1
	STDEV	3.6	11.5	19.3	1.0	2.9	22.4
	MIN	54	1	0	18	3	105
	MAX	72	69	55	23	16	205
	VALIDN	138					
NOV:	PCT	32.4	28.0	25.1	10.5	4.0	100.0
	MEAN	61.3	53.0	47.4	19.8	7.6	189.1
	STDEV	5.1	22.1	5.9	1.1	3.5	28.0
	MIN	46	0	31	17	3	115
	MAX	71	73	54	22	17	222
	VALIDN	419					
DEC:	PCT	30.0	26.5	30.3	9.7	3.5	100.0
	MEAN	59.3	52.4	60.0	19.3	6.9	198.0
	STDEV	5.0	23.6	3.8	1.1	3.4	29.4
	MIN	45	0	49	17	2	126
	MAX	69	73	65	22	17	232
	VALIDN	744					
TOT:	PCT	36.5	30.9	16.8	11.6	4.2	100.0
	MEAN	63.8	53.9	29.3	20.3	7.4	174.6
	STDEV	5.8	19.8	23.1	1.4	3.0	30.6
	MIN	42	0	0	7	2	85
	MAX	78	74	65	25	17	232
	VALIDN	2878					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1985 THROUGH JUN 1985

MONTH		REFRIG	LIGHTS	HPUMP	VENT	PROCESS	TOTAL
JAN:	PCT	29.7	26.0	31.4	9.5	3.5	100.0
	MEAN	60.6	53.1	64.0	19.4	7.2	204.3
	STDEV	4.7	22.7	1.7	1.2	3.4	28.1
	MIN	46	0	60	17	2	134
	MAX	72	73	69	22	16	237
	VALIDN	744					
FEB:	PCT	31.4	27.7	27.5	9.6	3.8	100.0
	MEAN	63.3	56.0	55.5	19.4	7.7	201.9
	STDEV	5.4	21.5	11.9	1.2	3.2	29.4
	MIN	48	0	18	17	3	108
	MAX	77	74	67	22	18	239
	VALIDN	671					
MAR:	PCT	34.1	29.7	21.8	10.4	4.0	100.0
	MEAN	64.1	55.7	40.9	19.5	7.4	187.7
	STDEV	4.3	21.8	10.3	1.2	3.1	28.6
	MIN	51	0	16	18	3	101
	MAX	75	73	64	23	18	229
	VALIDN	742					
APR:	PCT	33.9	30.9	19.6	11.2	4.5	100.0
	MEAN	60.5	55.1	35.0	19.9	8.0	178.6
	STDEV	4.3	22.0	12.0	1.2	3.0	29.7
	MIN	46	0	13	17	3	98
	MAX	70	73	60	24	17	225
	VALIDN	718					
MAY:	PCT	38.4	35.2	8.7	12.7	4.9	100.0
	MEAN	61.7	56.6	14.0	20.3	7.9	160.6
	STDEV	5.0	20.3	11.3	1.2	3.1	26.8
	MIN	44	0	2	18	3	80
	MAX	73	74	39	24	19	204
	VALIDN	743					
JUN:	PCT	40.8	36.9	3.5	13.3	5.5	100.0
	MEAN	62.3	56.3	5.3	20.3	8.4	152.6
	STDEV	5.7	19.9	7.2	1.0	2.8	25.1
	MIN	43	0	1	18	4	79
	MAX	74	73	30	24	16	186
	VALIDN	684					
TOT:	PCT	34.3	30.6	19.8	10.9	4.3	100.0
	MEAN	62.1	55.4	35.9	19.8	7.8	181.0
	STDEV	5.1	21.4	23.0	1.2	3.1	34.0
	MIN	43	0	1	17	2	79
	MAX	77	74	69	24	19	239
	VALIDN	4302					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1985 THROUGH DEC 1985

MONTH		REFRIG	LIGHTS	HPUMP	VENT	PROCESS	TOTAL
JUL:	PCT	42.8	35.5	2.5	13.4	5.7	100.0
	MEAN	66.3	55.0	3.9	20.8	8.8	154.9
	STDEV	5.0	19.3	3.4	1.2	2.4	23.6
	MIN	47	0	1	18	4	84
	MAX	76	71	10	24	15	182
	VALIDN	743					
AUG:	PCT	41.9	36.0	3.6	13.2	5.4	100.0
	MEAN	64.9	55.8	5.5	20.4	8.3	154.9
	STDEV	4.7	20.0	2.0	1.2	2.6	24.6
	MIN	54	0	3	18	4	85
	MAX	77	72	12	24	15	183
	VALIDN	742					
SEP:	PCT	40.8	36.1	5.3	12.9	4.9	100.0
	MEAN	62.7	55.5	8.1	19.9	7.5	153.7
	STDEV	4.4	20.7	7.4	1.1	2.6	25.7
	MIN	51	1	2	17	3	82
	MAX	73	72	24	24	16	190
	VALIDN	718					
OCT:	PCT	37.0	32.5	14.8	11.5	4.1	100.0
	MEAN	62.3	54.7	25.0	19.4	6.8	168.2
	STDEV	4.3	21.8	7.2	1.0	2.8	26.4
	MIN	51	1	17	17	2	99
	MAX	74	71	42	22	16	204
	VALIDN	720					
NOV:	PCT	33.6	29.9	21.8	11.1	3.5	100.0
	MEAN	58.5	52.1	37.8	19.4	6.1	173.9
	STDEV	5.8	23.4	5.9	1.3	2.5	27.4
	MIN	44	0	29	17	2	102
	MAX	79	72	47	24	14	213
	VALIDN	717					
DEC:	PCT	33.7	24.5	27.8	10.7	3.3	100.0
	MEAN	60.8	44.3	50.2	19.3	6.0	180.5
	STDEV	13.2	29.0	16.8	3.5	2.4	36.5
	MIN	0	0	29	0	2	49
	MAX	86	74	69	24	15	231
	VALIDN	473					
TOT:	PCT	38.4	32.7	12.2	12.2	4.5	100.0
	MEAN	62.7	53.5	19.9	19.9	7.4	163.3
	STDEV	6.9	22.4	18.3	1.7	2.8	28.8
	MIN	0	0	1	0	2	49
	MAX	86	74	69	24	16	231
	VALIDN	4113					

SUMMARY DATA: RESTAURANT #1

CHARACTERISTICS

Square feet	2,490
Year built	1976
Shell materials	Concrete
Principal use	Restaurant

Appliances	
Space Heat	Gas
Hot water	Electric
Air conditioning	Electric
Equipment 1	Electric fryer
Equipment 2	Gas stove

LOADS

Billed consumption	City Light Kwh	Gas Therms
1980	354,720	5,803.90
1981	310,620	5,903.20
1982	335,100	10,744.1
1983	289,080	7,169.80
1984	297,300	Not available
1985	266,460	Not available

Use/ft2 - 6-year average in kwh	124.0	87.1
Use/ft2 - 1985	107.0	
City Light forecast use/ft2	35.0	
Regional forecast use/ft2	45.6	

1985 Hourly End-Use Data (kwh/yr)

Electric End Uses	Kwh	Kwh/ sq.ft.	Percent
HVAC	24,820	10.0	8.6
Hot water	17,520	7.0	6.1
Lights	59,860	24.0	20.8
Refrigeration	48,180	19.4	16.8
Elevator	0	0	0
Misc equipment	137,240	55.1	47.7
TOTAL	287,620*	115.5*	100.0

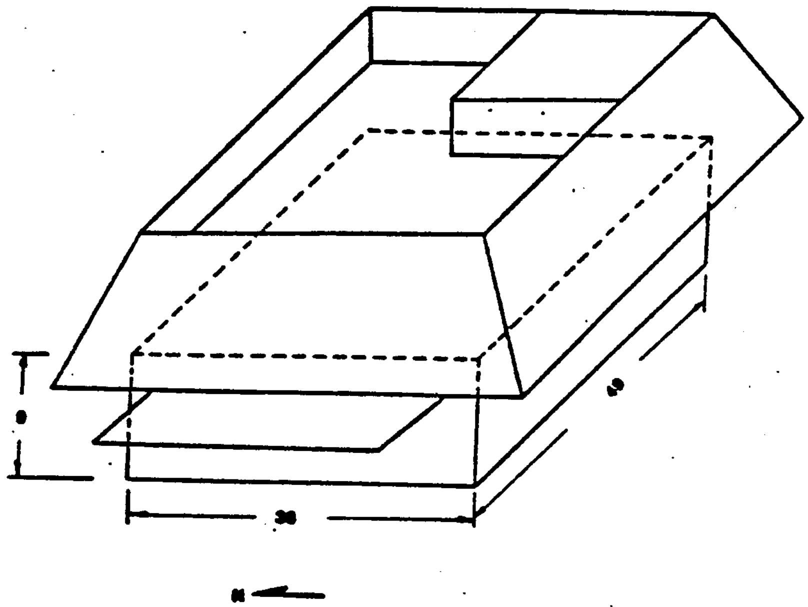
CONSERVATION PACKAGE	Estimated 1984 Costs	Simple Payback	Savings
Exterior lighting control	$ 667	1.6	Elec
Exhaust fan shutoff	737	4.4	Elec
Night setback	243	4.7	
TOTAL	$1,647	3 yrs - Elec 1 yr - Gas	

TOTAL ANNUAL ELECTRIC SAVINGS = 16.0 Mwh

Peak 0.0% Intermediate 8.7% Off Peak 91.3%

*Within the accuracy range of the monitoring equipment.

Restaurant #1



CHEUS restaurant #1 is typical one-story, fast-food restaurant with both inside dining and drive-up window service. Hours of operation are from 6 a.m. to midnight in the dining area, and until 2 a.m. at the drive-up window. On weekends the restaurant is open 24 hours a day. The average number of customers per hour on weekdays is 15 and 25 on weekends. Built in 1976, the building was constructed on a concrete slab with walls of concrete and a built-up roof over a plywood deck. The total floor area is 2,490 sq.ft. Sixty-one percent of this space is work area and 39 percent is dining area. The HVAC system consists of a single-zone unit with cooling and natural gas heating. This system is manually controlled with thermostats set at 70° F for heating and 75° F for cooling. Interior lighting is a mix of fluorescent and incandescent. Exterior lighting is fluorescent around the perimeter of the building and mercury vapor in the parking lot.

The principal end-use loads in this building are food processing equipment such as french fryers, malt machines, and the grill (47 percent of the total energy consumption); space heating (8.6 percent); and refrigeration (16.8 percent). Natural gas is used for cooking (the grill) and space heating. All other end uses are electrical. The 1985 annual electrical consumption was 266,460 kwh with an average 45-kw demand. The average annual natural gas consumption is approximately 3,600 therms. This facility consumes the equivalent of 720,273 Btu/sq.ft./year.

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1983 THROUGH DEC 1983

MONTH		PROCESS	REFRIG	LIGHTS	COOLING	HOT WATER	TOTAL
JUL:	PCT	46.6	15.7	15.5	16.2	6.2	100.0
	MEAN	17.7	6.0	5.9	6.2	2.4	38.0
	STDEV	4.2	.5	1.5	2.7	.9	6.4
	MIN	2	4	0	4	0	14
	MAX	28	8	8	16	4	52
	VALIDN	652					
AUG:	PCT	49.8	15.5	16.4	12.2	5.9	100.0
	MEAN	17.5	5.5	5.8	4.3	2.1	35.1
	STDEV	4.3	.6	1.4	2.7	.9	6.4
	MIN	4	3	1	2	0	14
	MAX	27	7	9	15	4	50
	VALIDN	741					
SEP:	PCT	54.3	14.6	17.5	6.9	6.4	100.0
	MEAN	18.0	4.9	5.8	2.3	2.1	33.3
	STDEV	4.2	.7	1.3	.8	.8	5.1
	MIN	2	2	1	2	0	11
	MAX	27	6	8	7	3	43
	VALIDN	708					
OCT:	PCT	56.3	12.9	17.6	6.2	7.2	100.0
	MEAN	18.3	4.2	5.7	2.0	2.3	32.4
	STDEV	4.2	.4	1.3	.0	.9	5.0
	MIN	3	2	0	2	0	13
	MAX	27	5	8	2	3	42
	VALIDN	601					
NOV:	PCT	53.4	16.6	17.0	6.2	6.4	100.0
	MEAN	17.3	5.4	5.5	2.0	2.1	32.4
	STDEV	4.6	.6	1.3	.1	1.1	5.9
	MIN	2	3	0	2	0	8
	MAX	25	7	9	3	3	42
	VALIDN	545					
DEC:	PCT	52.4	16.0	16.3	8.1	6.9	100.0
	MEAN	16.7	5.1	5.2	2.6	2.2	31.9
	STDEV	4.9	.5	1.5	1.1	1.1	6.2
	MIN	3	3	0	2	0	14
	MAX	25	6	7	6	3	42
	VALIDN	743					
TOT:	PCT	51.9	15.2	16.6	9.6	6.5	100.0
	MEAN	17.6	5.2	5.6	3.3	2.2	33.9
	STDEV	4.4	.8	1.4	2.3	1.0	6.3
	MIN	2	2	0	2	0	8
	MAX	28	8	9	16	4	52
	VALIDN	3990					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1984 THROUGH JUN 1984

MONTH		PROCESS	REFRIG	LIGHTS	COOLING	HOT WATER	TOTAL
JAN:	PCT	52.9	15.1	16.0	9.3	6.2	100.0
	MEAN	18.5	5.3	5.6	3.3	2.2	35.0
	STDEV	4.7	.6	1.2	1.5	1.1	5.9
	MIN	3	3	0	2	0	14
	MAX	28	6	7	8	3	45
	VALIDN	721					
FEB:	PCT	53.4	16.4	16.6	6.5	6.8	100.0
	MEAN	17.5	5.4	5.4	2.1	2.2	32.8
	STDEV	4.2	.6	1.2	.6	1.0	5.3
	MIN	2	3	1	2	0	13
	MAX	26	6	7	6	3	42
	VALIDN	462					
MAR:	PCT	53.3	17.2	16.6	7.1	6.1	100.0
	MEAN	17.4	5.6	5.4	2.3	2.0	32.6
	STDEV	4.0	.5	1.3	.8	1.0	5.1
	MIN	5	3	1	2	0	16
	MAX	25	6	8	6	3	42
	VALIDN	324					
APR:	PCT	52.5	16.9	18.1	6.6	6.2	100.0
	MEAN	17.4	5.6	6.0	2.2	2.0	33.2
	STDEV	4.3	.6	1.6	.6	1.1	5.5
	MIN	2	3	1	2	0	12
	MAX	26	6	8	8	3	44
	VALIDN	716					
MAY:	PCT	53.4	17.0	16.6	7.2	6.0	100.0
	MEAN	17.8	5.6	5.5	2.4	2.0	33.3
	STDEV	4.2	.6	1.4	.7	1.1	5.3
	MIN	3	3	0	2	0	13
	MAX	26	7	8	5	3	46
	VALIDN	743					
JUN:	PCT	52.2	16.1	16.7	9.8	5.4	100.0
	MEAN	18.5	5.7	5.9	3.5	1.9	35.4
	STDEV	4.4	.6	1.4	1.5	1.1	5.9
	MIN	3	3	1	2	0	11
	MAX	27	7	11	9	3	46
	VALIDN	719					
TOT:	PCT	52.9	16.4	16.8	7.9	6.0	100.0
	MEAN	17.9	5.5	5.7	2.7	2.1	33.9
	STDEV	4.4	.6	1.4	1.2	1.1	5.7
	MIN	2	3	0	2	0	11
	MAX	28	7	11	9	3	46
	VALIDN	3685					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1984 THROUGH DEC 1984

MONTH		PROCESS	REFRIG	LIGHTS	COOLING	HOT WATER	TOTAL
JUL:	PCT	50.4	15.7	16.3	12.9	4.9	100.0
	MEAN	18.3	5.7	5.9	4.7	1.8	36.4
	STDEV	4.4	.6	1.4	1.8	1.2	6.1
	MIN	4	3	1	2	0	12
	MAX	27	7	9	9	3	48
	VALIDN	744					
AUG:	PCT	51.0	15.8	15.9	12.5	4.9	100.0
	MEAN	18.6	5.8	5.8	4.5	1.8	36.5
	STDEV	4.3	.6	1.5	1.8	1.2	6.3
	MIN	4	3	0	1	0	14
	MAX	26	7	9	9	3	49
	VALIDN	742					
SEP:	PCT	52.8	15.9	16.8	9.3	5.5	100.0
	MEAN	19.1	5.7	6.1	3.3	2.0	36.1
	STDEV	4.0	.6	1.3	1.4	1.1	5.5
	MIN	2	3	0	2	0	13
	MAX	28	7	9	8	3	48
	VALIDN	719					
OCT:	PCT	54.1	15.7	17.1	6.4	6.8	100.0
	MEAN	19.0	5.5	6.0	2.3	2.4	35.2
	STDEV	4.2	.6	1.4	.6	1.0	5.4
	MIN	4	3	1	2	0	15
	MAX	29	7	8	5	3	47
	VALIDN	743					
NOV:	PCT	54.5	15.1	17.0	5.7	7.7	100.0
	MEAN	19.2	5.3	6.0	2.0	2.7	35.3
	STDEV	4.2	.7	1.4	.0	.7	5.3
	MIN	5	3	1	2	0	17
	MAX	25	6	7	2	3	43
	VALIDN	290					
DEC:	PCT	54.4	15.7	17.0	6.1	6.9	100.0
	MEAN	17.8	5.1	5.6	2.0	2.3	32.7
	STDEV	5.3	.7	1.8	.0	1.1	7.2
	MIN	3	3	0	2	0	9
	MAX	28	6	10	2	3	43
	VALIDN	672					
TOT:	PCT	52.6	15.7	16.6	9.3	5.9	100.0
	MEAN	18.6	5.6	5.9	3.3	2.1	35.4
	STDEV	4.5	.7	1.5	1.7	1.1	6.2
	MIN	2	3	0	1	0	9
	MAX	29	7	10	9	3	49
	VALIDN	3910					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1985 THROUGH JUN 1985

MONTH		PROCESS	REFRIG	LIGHTS	COOLING	HOT WATER	TOTAL
JAN:	PCT	53.8	16.6	18.2	6.1	5.9	100.0
	MEAN	17.5	5.4	5.9	2.0	1.9	32.6
	STDEV	4.0	.5	1.6	.3	1.1	5.5
	MIN	4	4	1	1	0	11
	MAX	25	6	7	4	3	40
	VALIDN	325					
FEB:	PCT	52.4	16.2	17.8	6.9	7.1	100.0
	MEAN	17.4	5.4	5.9	2.3	2.4	33.2
	STDEV	4.6	.5	1.6	.9	.9	5.9
	MIN	3	3	0	2	0	12
	MAX	26	6	7	5	3	44
	VALIDN	671					
MAR:	PCT	49.5	17.5	19.4	6.8	7.0	100.0
	MEAN	15.6	5.5	6.1	2.1	2.2	31.6
	STDEV	3.6	.6	1.5	.5	1.1	4.9
	MIN	1	3	0	2	0	7
	MAX	22	7	7	5	3	40
	VALIDN	731					
APR:	PCT	47.9	18.0	20.8	6.3	6.9	100.0
	MEAN	15.2	5.7	6.6	2.0	2.2	31.6
	STDEV	3.7	.6	1.8	.0	1.1	5.3
	MIN	3	3	0	2	0	13
	MAX	22	7	8	3	3	40
	VALIDN	712					
MAY:	PCT	47.5	18.5	19.7	7.2	6.7	100.0
	MEAN	14.9	5.8	6.2	2.3	2.1	31.5
	STDEV	3.7	.6	1.6	.6	1.1	5.2
	MIN	2	3	0	2	0	12
	MAX	22	7	9	5	3	40
	VALIDN	743					
JUN:	PCT	47.1	17.7	18.4	10.8	6.4	100.0
	MEAN	15.5	5.8	6.1	3.6	2.1	33.0
	STDEV	3.7	.4	1.3	1.4	1.2	5.0
	MIN	3	4	1	2	0	16
	MAX	23	7	9	8	3	42
	VALIDN	717					
TOT:	PCT	49.3	17.5	19.1	7.5	6.7	100.0
	MEAN	15.9	5.6	6.2	2.4	2.2	32.2
	STDEV	4.0	.6	1.6	1.0	1.1	5.3
	MIN	1	3	0	1	0	7
	MAX	26	7	9	8	3	44
	VALIDN	3899					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1985 THROUGH DEC 1985

MONTH		PROCESS	REFRIG	LIGHTS	COOLING	HT WATER	TOTAL
JUL:	PCT	48.3	16.9	17.2	13.1	4.8	100.0
	MEAN	16.8	5.9	6.0	4.6	1.7	34.7
	STDEV	3.6	.7	1.4	1.7	1.2	5.3
	MIN	4	3	1	2	0	15
	MAX	23	7	8	10	3	46
	VALIDN	739					
AUG:	PCT	49.3	16.7	16.4	13.7	4.6	100.0
	MEAN	17.0	5.7	5.7	4.7	1.6	34.5
	STDEV	3.4	.6	1.5	1.3	1.0	4.6
	MIN	3	3	1	2	0	15
	MAX	26	7	9	9	3	46
	VALIDN	738					
SEP:	PCT	51.6	16.3	18.9	8.2	5.5	100.0
	MEAN	16.7	5.3	6.1	2.6	1.8	32.3
	STDEV	3.7	.8	1.3	1.2	1.0	4.6
	MIN	1	3	1	2	0	13
	MAX	24	6	8	6	3	40
	VALIDN	715					
OCT:	PCT	43.0	16.3	28.0	6.0	6.3	100.0
	MEAN	13.6	5.2	8.9	1.9	2.0	31.7
	STDEV	3.2	.9	3.1	.8	1.0	5.2
	MIN	3	3	1	0	0	11
	MAX	23	7	12	5	3	43
	VALIDN	742					
NOV:	PCT	40.7	16.4	30.1	5.2	7.3	100.0
	MEAN	12.6	5.1	9.3	1.6	2.2	30.9
	STDEV	3.0	.9	2.9	1.0	1.0	5.7
	MIN	3	3	1	0	0	9
	MAX	18	7	12	7	4	44
	VALIDN	705					
DEC:	PCT	39.7	16.6	28.7	7.8	7.4	100.0
	MEAN	12.9	5.4	9.3	2.5	2.4	32.4
	STDEV	3.5	1.0	2.8	1.5	1.0	6.4
	MIN	2	3	0	1	0	13
	MAX	20	8	12	7	4	44
	VALIDN	739					
TOT:	PCT	45.5	16.5	23.0	9.2	5.9	100.0
	MEAN	14.9	5.4	7.5	3.0	1.9	32.8
	STDEV	3.9	.9	2.8	1.8	1.1	5.5
	MIN	1	3	0	0	0	9
	MAX	26	8	12	10	4	46
	VALIDN	4378					

SUMMARY DATA: RESTAURANT #2

CHARACTERISTICS

Square feet	3,252
Year built	1970
Shell materials	Wood
Principal use	Restaurant
Appliances	
Space Heat	Gas
Hot water	Gas
Equipment	Gas stove
Air conditioning	Electric

LOADS

Billed consumption	City Light Kwh	Gas Therms
1980	306,360	29,103.7
1981	330,720	28,895.8
1982	333,000	31,360.7
1983	337,800	29,361.4
1984	343,440	Not available
1985	342,000	Not available
Use/ft2 - 6-year average in kwh	102.2	267.4
Use/ft2 - 1985	105.2	
City Light forecast use/ft2	35.0	
Regional forecast use/ft2	45.6	

1985 Hourly End-Use Data (kwh/yr)

Electric End Uses	Kwh	Kwh/ sq.ft.	Percent
HVAC	40,880	12.6	11.9
Hot water	0	0	0
Lights	94,900	29.2	27.5
Refrigeration	41,610	12.8	12.1
Elevator	0	0	0
Misc equipment	167,170	51.4	48.5
TOTAL	344,560*	106.0*	100.0

CONSERVATION PACKAGE

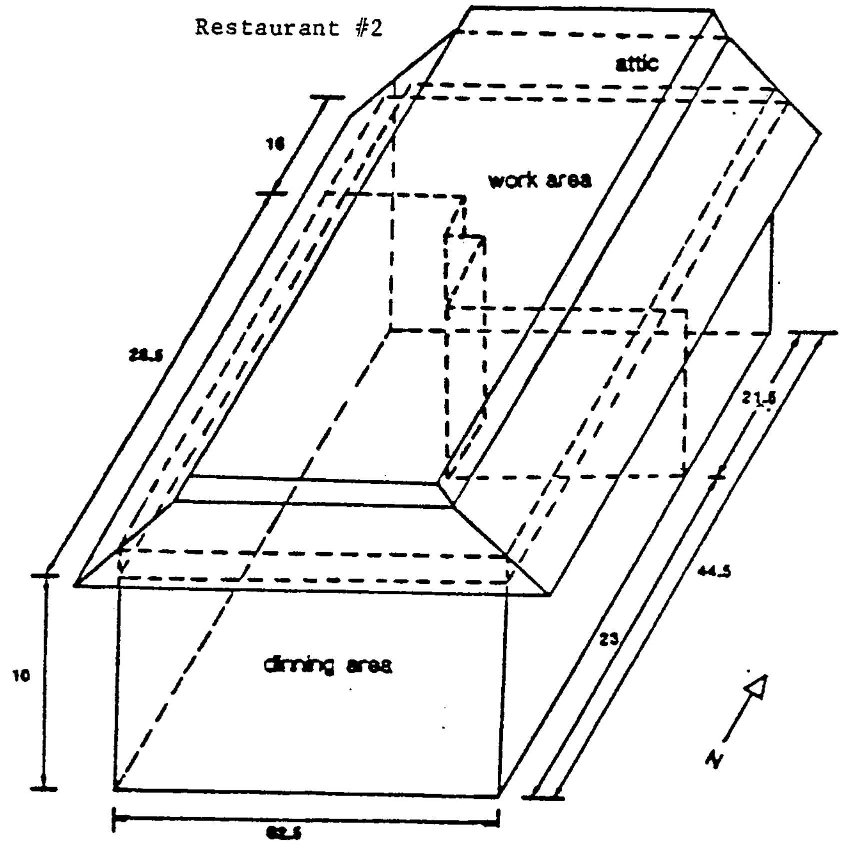
	Estimated 1984 Costs	Simple Payback	Savings
Outside air reduction	$ 155	0.1	Gas
Walk-in strip curtains	337	3.4	Elec
Range hood modifications	18,721	2.4	Gas
Exterior light controls	5,548	12.3	Elec
TOTAL	$24,861	10 yrs elec 2 yrs gas	

TOTAL ANNUAL ELECTRIC SAVINGS = 18.1 Mwh

Peak 2.8% Intermediate 9.9% Off Peak 87.3%

*Within the accuracy range of the monitoring equipment.

Restaurant #2



CHEUS restaurant #2 is a typical one-story, 24-hour "coffee shop" restaurant that is open seven days a week. The average number of customers per hour is 56. Built in 1970, the building was constructed on a concrete slab on grade with wood-framed walls and a built-up roof over a plywood deck. The total floor area is 3,252 sq.ft. Seventy-one percent of this space is dining area and 29 percent is work area. Twenty-eight percent of the total wall area is glass. The HVAC system consists of two packaged rooftop units. This system is manually controlled with thermostats set for heating at 64° F in the dining area and 68° F in the work area. Both areas have a cooling temperature of 73° F. Interior lighting in the dining area is incandescent with fluorescent in the work area. Exterior lighting is mixed incandescent, mercury vapor, and fluorescent.

The principal end-use loads in this building are food processing equipment such as range and broilers (48.5 percent of total energy consumption), space heating (11.9 percent), lighting (27.5 percent), and refrigeration (12.1 percent). Natural gas is used for cooking (range and broilers), space heating, and domestic hot water. All other end uses are electrical. The 1985 annual electrical consumption was 342,000 kwh with an average 57-kw demand. The average annual natural gas consumption is approximately 29,500 therms. This facility consumes the equivalent of 1,256,980 Btu/sq.ft./year.

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

SEP 1983 THROUGH FEB 1984

MONTH		LGPROCESS	LIGHTS	SMPROCESS	REFRIG	VENTCOOL	TOTAL
SEP:	PCT	34.9	26.8	13.9	11.5	15.6	100.0
	MEAN	13.5	10.3	5.4	4.4	6.0	38.6
	STDEV	.7	2.8	.6	.6	3.5	3.4
	MIN	10	7	4	3	2	31
	MAX	15	14	7	5	12	47
	VALIDN	720					
OCT:	PCT	35.3	29.9	15.6	11.7	10.0	100.0
	MEAN	12.8	10.8	5.6	4.3	3.6	36.3
	STDEV	1.1	2.7	.7	.5	2.6	3.1
	MIN	9	7	4	3	1	29
	MAX	15	14	8	5	12	45
	VALIDN	589					
NOV:	PCT	36.4	31.6	16.6	11.4	5.7	100.0
	MEAN	13.1	11.4	6.0	4.1	2.0	36.1
	STDEV	.7	2.4	.8	.4	.4	2.0
	MIN	11	7	5	3	2	31
	MAX	14	14	8	5	8	41
	VALIDN	227					
DEC:	PCT	37.2	31.6	16.6	11.3	5.7	100.0
	MEAN	13.2	11.2	5.9	4.0	2.0	35.5
	STDEV	1.0	2.6	.8	.4	.5	2.5
	MIN	8	6	4	3	0	24
	MAX	15	14	8	5	9	41
	VALIDN	646					
JAN:	PCT	36.8	31.3	16.5	11.8	5.8	100.0
	MEAN	13.0	11.1	5.8	4.2	2.1	35.3
	STDEV	1.2	2.7	.8	.4	.5	2.7
	MIN	4	6	3	3	0	19
	MAX	15	14	8	5	9	45
	VALIDN	744					
FEB:	PCT	35.6	31.4	17.2	12.2	6.2	100.0
	MEAN	12.2	10.7	5.9	4.2	2.1	34.1
	STDEV	1.7	2.8	.8	.4	.7	2.5
	MIN	7	7	4	3	2	26
	MAX	15	14	8	5	10	42
	VALIDN	694					
TOT:	PCT	36.0	30.2	16.0	11.7	8.6	100.0
	MEAN	12.9	10.9	5.7	4.2	3.1	36.0
	STDEV	1.3	2.7	.8	.5	2.5	3.2
	MIN	4	6	3	3	0	19
	MAX	15	14	8	5	12	47
	VALIDN	3620					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1984 THROUGH JUN 1984

MONTH		LGPROCESS	LIGHTS	SMPROCESS	REFRIG	VENTCOOL	TOTAL
JAN:	PCT	36.8	31.3	16.5	11.8	5.8	100.0
	MEAN	13.0	11.1	5.8	4.2	2.1	35.3
	STDEV	1.2	2.7	.8	.4	.5	2.7
	MIN	4	6	3	3	0	19
	MAX	15	14	8	5	9	45
	VALIDN	744					
FEB:	PCT	35.6	31.4	17.2	12.2	6.2	100.0
	MEAN	12.2	10.7	5.9	4.2	2.1	34.1
	STDEV	1.7	2.8	.8	.4	.7	2.5
	MIN	7	7	4	3	2	26
	MAX	15	14	8	5	10	42
	VALIDN	694					
MAR:	PCT	34.5	30.6	17.3	12.4	8.0	100.0
	MEAN	11.9	10.5	6.0	4.3	2.7	34.4
	STDEV	1.8	2.6	.8	.5	2.0	2.7
	MIN	7	7	4	3	2	26
	MAX	14	14	9	6	12	43
	VALIDN	743					
APR:	PCT	35.4	29.6	17.4	12.3	8.1	100.0
	MEAN	12.0	10.1	5.9	4.2	2.7	34.0
	STDEV	1.6	2.7	.8	.4	2.1	2.6
	MIN	8	7	4	3	2	27
	MAX	14	14	8	5	12	43
	VALIDN	556					
MAY:	PCT	33.7	26.7	17.2	11.9	13.3	100.0
	MEAN	12.2	9.7	6.2	4.3	4.8	36.2
	STDEV	1.5	2.6	.9	.5	3.2	3.6
	MIN	6	6	4	3	2	22
	MAX	15	14	9	6	12	47
	VALIDN	742					
JUN:	PCT	32.7	23.8	16.1	11.5	18.9	100.0
	MEAN	12.9	9.4	6.4	4.5	7.4	39.4
	STDEV	1.2	2.8	.8	.5	3.6	3.3
	MIN	8	7	5	4	1	29
	MAX	15	13	9	6	12	49
	VALIDN	719					
TOT:	PCT	34.7	28.7	16.9	12.0	10.3	100.0
	MEAN	12.4	10.2	6.0	4.3	3.7	35.6
	STDEV	1.6	2.8	.8	.5	3.0	3.5
	MIN	4	6	3	3	0	19
	MAX	15	14	9	6	12	49
	VALIDN	4198					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1984 THROUGH DEC 1984

MONTH		LGPROCESS	LIGHTS	SMPROCESS	REFRIG	VENTCOOL	TOTAL
JUL:	PCT	32.0	23.2	15.1	11.5	21.8	100.0
	MEAN	13.1	9.5	6.2	4.7	8.9	41.0
	STDEV	1.0	2.8	.7	.6	3.8	3.1
	MIN	8	7	5	4	2	32
	MAX	15	14	8	6	12	49
	VALIDN	744					
AUG:	PCT	32.8	24.0	14.7	11.4	20.5	100.0
	MEAN	13.6	9.9	6.1	4.7	8.5	41.3
	STDEV	.7	2.9	.7	.5	4.0	3.2
	MIN	10	7	5	4	2	32
	MAX	15	14	8	6	12	49
	VALIDN	740					
SEP:	PCT	34.5	25.4	15.4	11.9	15.8	100.0
	MEAN	13.8	10.1	6.2	4.8	6.3	40.0
	STDEV	.5	3.1	.7	.5	4.2	2.6
	MIN	13	7	5	4	2	33
	MAX	15	14	7	6	12	45
	VALIDN	49					
OCT:	PCT	37.7	29.9	17.0	12.0	5.6	100.0
	MEAN	13.6	10.8	6.1	4.3	2.0	36.1
	STDEV	.6	2.9	.7	.5	.2	2.4
	MIN	12	7	5	4	2	31
	MAX	15	14	8	5	5	42
	VALIDN	209					
NOV:	PCT	37.4	30.7	16.9	11.7	5.5	100.0
	MEAN	13.5	11.1	6.1	4.2	2.0	36.2
	STDEV	.6	2.8	.7	.4	.0	2.4
	MIN	12	7	5	4	2	30
	MAX	15	14	8	5	2	42
	VALIDN	686					
DEC:	PCT	37.4	31.0	17.1	11.1	5.6	100.0
	MEAN	13.6	11.3	6.2	4.0	2.0	36.4
	STDEV	.6	2.7	.7	.3	.5	2.4
	MIN	12	7	4	3	2	31
	MAX	15	14	8	5	12	42
	VALIDN	743					
TOT:	PCT	34.9	27.1	15.9	11.5	13.5	100.0
	MEAN	13.5	10.5	6.1	4.4	5.2	38.6
	STDEV	.8	2.9	.7	.5	4.3	3.7
	MIN	8	7	4	3	2	30
	MAX	15	14	8	6	12	49
	VALIDN	3171					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JAN 1985 THROUGH JUN 1985

MONTH		LGPROCESS	LIGHTS	SM PROC	REFRIG	VENTCOOL	TOTAL
JAN:	PCT	37.3	31.0	17.2	11.1	5.5	100.0
	MEAN	13.5	11.2	6.2	4.0	2.0	36.2
	STDEV	.6	2.7	.8	.2	.0	2.3
	MIN	12	7	5	3	2	30
	MAX	15	14	9	5	2	42
	VALIDN	423					
FEB:	PCT	37.9	31.0	16.1	11.5	6.3	100.0
	MEAN	13.4	11.0	5.7	4.1	2.2	35.4
	STDEV	.6	2.9	.7	.3	1.1	2.6
	MIN	12	7	4	3	2	30
	MAX	15	14	7	5	12	41
	VALIDN	326					
MAR:	PCT	37.9	30.7	16.4	11.9	5.8	100.0
	MEAN	13.5	10.9	5.8	4.2	2.1	35.6
	STDEV	.7	2.8	.7	.5	.8	2.6
	MIN	10	7	5	3	2	29
	MAX	15	14	8	5	12	46
	VALIDN	561					
APR:	PCT	34.6	29.6	16.7	12.4	9.4	100.0
	MEAN	12.6	10.8	6.1	4.5	3.4	36.5
	STDEV	1.5	3.0	.8	.5	2.8	3.2
	MIN	9	7	5	4	2	31
	MAX	14	14	8	6	12	47
	VALIDN	137					
MAY:	PCT	33.0	27.7	16.1	12.5	13.6	100.0
	MEAN	12.6	10.6	6.1	4.8	5.2	38.1
	STDEV	1.5	3.0	.7	.6	3.8	3.7
	MIN	8	7	5	4	2	29
	MAX	15	14	8	6	12	49
	VALIDN	742					
JUN:	PCT	31.4	26.1	14.9	12.5	18.0	100.0
	MEAN	12.7	10.6	6.0	5.1	7.3	40.5
	STDEV	1.3	2.9	.7	.6	3.7	3.3
	MIN	8	7	4	4	2	28
	MAX	15	14	8	6	12	49
	VALIDN	719					
TOT:	PCT	34.7	28.7	16.0	12.1	11.3	100.0
	MEAN	13.0	10.8	6.0	4.5	4.2	37.6
	STDEV	1.2	2.9	.8	.6	3.5	3.7
	MIN	8	7	4	3	2	28
	MAX	15	14	9	6	12	49
	VALIDN	2908					

AVERAGE HOURLY KWH FOR THE
COMMERCIAL HOURLY END-USE STUDY
BY MONTH

JUL 1985 THROUGH DEC 1985

MONTH		LGPROCESS	LIGHTS	SM PROC	REFRIG	VENTCOOL	TOTAL
JUL:	PCT	29.4	24.0	13.7	12.1	24.6	100.0
	MEAN	12.9	10.5	6.0	5.3	10.7	43.7
	STDEV	1.2	2.9	.7	.6	2.1	2.8
	MIN	9	7	4	4	2	33
	MAX	15	14	9	7	12	50
	VALIDN	742					
AUG:	PCT	29.9	24.3	14.4	11.7	23.2	100.0
	MEAN	12.9	10.5	6.2	5.0	10.0	43.2
	STDEV	1.2	2.9	.7	.5	2.3	2.6
	MIN	9	7	5	4	2	34
	MAX	15	14	9	6	12	50
	VALIDN	516					
SEP:	PCT	31.7	26.2	16.1	11.9	17.0	100.0
	MEAN	12.7	10.5	6.5	4.8	6.8	40.1
	STDEV	1.4	2.9	.7	.5	3.6	3.5
	MIN	5	7	4	4	0	26
	MAX	15	14	8	6	12	49
	VALIDN	659					
OCT:	PCT	33.8	29.8	18.3	12.8	8.1	100.0
	MEAN	12.1	10.6	6.5	4.6	2.9	35.7
	STDEV	1.5	2.9	.8	.5	2.1	3.0
	MIN	8	7	5	4	2	29
	MAX	14	14	8	5	11	45
	VALIDN	315					
NOV:	PCT	33.2	30.4	18.3	14.4	5.6	100.0
	MEAN	11.8	10.8	6.5	5.1	2.0	35.6
	STDEV	1.6	2.9	.7	.8	.0	2.3
	MIN	7	7	5	4	2	29
	MAX	14	14	9	7	2	41
	VALIDN	263					
DEC:	PCT	32.1	30.9	18.5	13.5	4.3	100.0
	MEAN	11.5	11.1	6.6	4.8	1.5	35.9
	STDEV	1.7	2.8	.8	1.1	.5	2.7
	MIN	7	7	5	4	1	28
	MAX	14	14	9	7	4	43
	VALIDN	740					
TOT:	PCT	31.2	26.9	16.0	12.5	15.8	100.0
	MEAN	12.4	10.7	6.4	5.0	6.3	39.7
	STDEV	1.5	2.9	.8	.8	4.4	4.5
	MIN	5	7	4	4	0	26
	MAX	15	14	9	7	12	50
	VALIDN	3235					

Appendix B

Conservation Strategies
Simulation Results

PRIORITIZED LIST OF ENERGY CONSERVATION STRATEGIES

Retail Store #1

Order	ID	STRATEGY	ELECTRICAL[1] SAVINGS - MWH PEAK	INTERM	BASE	O&M($)	CAPITAL COSTS[2] (83$)/ (MILL/KWH)	PROJECT LIFE (YR)	B/C[3] MVCL/MTV	OPTIMIZATION RANK MVCL/MTV
1	PS8	Revise NSB[6] & fan sched	1.4	0.7	81.3	40	570 25.4	15	33.6 67.0	1 1
2	PS3	Add R-19 to ceiling	5.9	5.4	17.8	0	15,760 44.7	20	1.7 2.8	2 2
3	PS7	Install economizer	-0.0	2.1	42.3	40	9,420 19.9	15		3 3
4	PS2	Add R-10 to walls	4.8	6.5	15.1	120	28,970 44.3	20		
5	PS6	Vestibule & double glass	2.6	3.8	9.4	500	15,130 43.3	20		
6	PS9	Relamp[4] w/HID	-0.4	9.0	76.0	80	34,720	10		
7	PS5	Reduce DHW[5]	0.0	0.1	0.4	0	459	10		

1 Energy savings per year compared to the base case by implementing the given strategy. Negative savings indicate an increase in consumption.
2 Capital cost determined by converting present cost to 1983 dollars using an escalation factor of 3.5%.
3 Benefit to cost ratio. Strategy is cost effective if B/C ratio is greater than one.
4 High intensity discharge lighting sources.
5 Domestic hot water.
6 Night set back.

PRIORITIZED LIST OF ENERGY CONSERVATION STRATEGIES - MVCL and MTV

Retail Store #2

Order	ID	STRATEGY	ELECTRICAL[1] SAVINGS - MWH PEAK	INTERM	BASE	GAS SAVINGS THERMS	O&M($)	CAPITAL COSTS[2] (83$)/ (MILL/KWH)	PROJECT LIFE (YR)	B/C[3] MVCL/MTV	OPTIMIZATION RANK MVCL/MTV
1	S01	Reduce Light level	4.4	25.0	149.8	-5042.2	0	4,070 32.6	25	16.5 37.6	1 1
2	S05	Lock-out roof fans	0.0	0.0	0.0	4005.7	0	766 24.9	15	17.4 17.4	2 2
3	S10	Weather seal loading doors	0.0	0.0	0.0	973.2	0	225 23.9	8	11.9 11.9	3 3
4	S03	Int light controls	0.7	1.9	132.1	-4090.8	0	2,200 31.2	15	6.5 18.1	4 4
5	S06	Lock-out unit heaters	0.0	0.0	0.0	2496.3	0	1,290 24.9	15	6.6 6.6	5 5
6	S07	Night setback	0.0	0.0	0.0	4068.9	0	2,576 24.9	15	5.2 5.2	6 6
7	S04	Ext light controls	-0.0	-1.4	6.5	0.0	10	644 30.4	15	1.3 3.0	7 7
8	S08	Double glazing	0.0	0.0	0.0	1158.0	0	9,440 26.3	25		
9	S02	Retrofit ext lights	0.2	1.0	7.9	0.0	0	7,900 30.7	15		
10	S09	Insulate walls	0.0	0.0	0.0	5902.4	100	68,170 26.3	25		

[1] Energy savings per year compared to the base case by implementing the given strategy. Negative savings indicate an increase in consumption.
[2] Capital cost determined by converting present cost to 1983 dollars using an escalation factor of 3.5%.
[3] Benefit to cost ratio. Strategy is cost effective if B/C ratio is greater than one.
First entries indicate energy savings and B/C for MVCL; second entries indicate same for MTV.

PRIORITIZED LIST OF ENERGY CONSERVATION STRATEGIES - MVCL and MTV

Office Building #1

Order	ID	STRATEGY	ELECTRICAL[1] SAVINGS - MWH PEAK	INTERM	BASE	O&M($)	CAPITAL COSTS[2] (83$)/ (MILL/KWH)	PROJECT LIFE (YR)	B/C[3] MVCL/MTV	OPTIMIZATION RANK MVCL/MTV
1	OB1	Optimize heat recovery	2.4	6.5	-1.1	160	450 46.5	10	3.6 5.7	1 1
2	OB5	Light switches	-0.1	6.3	45.6	0	11,480 27.3	20	1.5 3.4	2 2
3	OB2	Automate vent	1.5	7.9	30.6	80	7,460 27.9	10	 6.0	3 3
4	OBA	Roof to R-20	5.9	17.3	21.4	0	34,890 40.5	20	 1.6	 4
5	OB6	Motion detectors	-8.1	-32.7	252.0	40	33,750 25.6	10	 3.4	 5
6	OB9	Reflective film	19.7	36.6	87.4	240	43,620 35.3	7	 1.6	 6
7	OBB	Double glazing	2.9	4.2	-7.8	0	229,565 52.8	30		
8	OB3	Optimize DHW[4]	0.0	0.2	1.1	20	712 28.9	20		
9	OB4	Delamp/ relamp	-1.7	5.7	191.0	0	50,628 25.3	7		
10	OB7	Waste heat storage tank	34.0	39.4	32.7	400	11,748 36.8	20		

[1] Energy savings per year compared to the base case by implementing the given strategy. Negative savings indicate an increase in consumption.
[2] Capital cost determined by converting present cost to 1983 dollars using an escalation factor of 3.5%.
[3] Benefit to cost ratio. Strategy is cost effective if B/C ratio is greater than one. First entries indicate energy savings and B/C for MVCL; second entries indicate same for MTV.
[4] Domestic hot water.

PRIORITIZED LIST OF ENERGY CONSERVATION STRATEGIES - MVCL and MTV

Office Building #2

Order	ID	STRATEGY	ELECTRICAL[1] CONSUMPTION/SAVINGS-MWH PEAK	INTERM	BASE	O&M($)	CAPITAL COSTS[2] (83$)/ (MILL/KWH)	PROJECT LIFE (YR)	B/C[3] MVCL/MTV	OPTIMATION RANK MVCL/MTV
1	EL02	Replace dampers	3.0	7.7	27.3	0	2,730 35.3	15	5.3 9.8	1 1
2	EL09	Photocell parking	0.0	0.3	2.9	0	220 28.0	15	4.3 9.1	2 2
3	EL08	HPS[4] parking	0.3	1.4	10.6	30	2,330 30.7	15	1.2 2.5	3 3
4	EL07	Time clocks	0.7	-1.5	34.3	20	7,460 33.3	15	1.3 2.5	4
5	EL03	Heat pump retrofit	4.1	14.4	59.3	500	37,800 34.2	15		
6	EL04	Roof to R-38	0.1	-0.3	1.3	0	8,280 44.3	25		
7	EL05	Floor to R-30	0.1	-0.4	-0.5	0	2,900 75.0	25		

1 Energy savings per year compared to the base case by implementing the given strategy. Negative savings indicate an increase in consumption.
2 Capital cost determined by converting present cost to 1983 dollars using an escalation factor of 3.5%.
3 Benefit to cost ratio. Strategy is cost effective if B/C ratio is greater than one. First entries indicate energy savings and B/C for MVCL; second entries indicate same for MTV.
4 High pressure sodium lighting sources.

PRIORITIZED LIST OF ENERGY CONSERVATION STRATEGIES - MVCL and MTV

Grocery #1

Order	ID	STRATEGY	PEAK	ELECTRICAL[1] CONSUMPTION/SAVINGS-MWH INTERM	BASE	O&M($)	CAPITAL COSTS[2] (83$)/ (MILLS/KWH)	PROJECT LIFE (YR)	B/C[3] MVCL/MTV	OPTIMIZATION RANK MVCL/MTV
1	S05	Shut off outside air	1.2	15.9	45.7	0	440 33.9	10	28.4 61.2	1 1
2	S03	Bank switching	0.6	-2.4	43.7	0	1,690 29.6	20	3.7 6.8	2 2
3	S04	Heat recovery	1.6	28.5	49.4	200	18,518 37.4	20	2.8 5.8	3 3
4	S09	Case curtains	0.6	5.1	26.1	500	3,437 31.9	15	1.5 3.2	4 4
5	S08	Add R-18 to ceiling	0.7	9.1	18.8	0	18,320 39.5	25	0.7 1.4	 5
6	S06	Double glazing	0.3	4.5	9.2	0	14,420 38.8	25		
7	S07	Add R-10 to walls	1.1	13.3	30.5	120	45,440 38.5	20		
8	S01	HID sales[4] lighting	2.3	3.9	66.4	80	45,560 27.7	10		
9	S02	HID storage[4] lighting	0.1	0.2	1.0	30	2,480 27.5	10		

1 Energy savings per year compared to the modified base case by implementing the given strategy. Negative savings indicate an increase in consumption.
2 Capital cost determined by converting present cost to 1983 dollars using an escalation factor of 3.5%.
3 Benefit to cost ratio. Strategy is cost effective if B/C ratio is greater than that one.
First entries indicate MCLV energy savings and B/C; second entries indicate same for MTV.
4 High intensity discharge lighting sources.

PRIORITIZED LIST OF ENERGY CONSERVATION STRATEGIES - MVCL and MTV

Grocery #2

Order	ID	STRATEGY	ELECTRICAL[1] CONSUMPTION/SAVINGS-MWH PEAK	INTERM	BASE	GAS SAVINGS THERMS	O&M($)	CAPITAL COSTS[2] (83$)/ (MILL/KWH)	PROJECT LIFE (YR)	B/C[3] MVCL/MTV	OPTIMIZATION RANK MVCL/MTV
1	S01	Reduce lighting	3.6	18.0	136.2	7262.5	0	1,667 28.3	15	14.0 43.3	1 1
2	S09	Auto Walk-in lights	0.1	0.5	3.9	0.0	0	163 28.4	15.8	8.2 16.9	2 2
3	S03	Interior light control	1.5	3.1	97.1	-4602.5	25	2,820 28.5	15	4.7 6.6	3 3
4	S02	Case curtains	1.1	5.7	43.9	1197.2	500	3,132 28.2	15	3.6 6.1	4 4
5	S08	Night setback	0.0	0.0	0.0	469.9	0	653 0	15	2.0 5.0	4 4
6	S06	Space heat recovery	-0.5	-2.3	-17.1	4124.0	100	8,660 28.2	15		5 5
7	S07	Electronic ignition	0.0	0.0	0.0	-117.4	0	1,223 0	15		
8	S04	Double glazing	0.0	0.0	0.0	708.3	0	7,806 0	25		
9	S10	DHW Heat[4] recovery	0.0	0.0	0.0	312.3	100	4,500 0	15		
10	S05	Insulate Walls	0.0	0.0	0.0	713.0	100	17,908 0	25		

1 Energy savings per year compared to the base case by implementing the given strategy. Negative savings indicate an increase in consumption.

2 Capital cost determined by converting present cost to 1983 dollars using an escalation factor of 3.5%.

3 Benefit to cost ratio. Strategy is cost effective if B/C ratio is greater than one. First entries indicate energy savings and B/C for MVCL; second entries indicate same for MTV.

4 Domestic hot water.

PRIORITIZED LIST OF ENERGY CONSERVATION STRATEGIES - MVCL and MTV

Restaurant #1

Order	ID	STRATEGY	ELECTRICAL[1] CONSUMPTION/SAVINGS-MWH PEAK	INTERM	BASE	GAS SAVINGS THERMS	O&M($)	CAPITAL COSTS[2] (83$)/ (MILL/KWH)	PROJECT LIFE (YR)	B/C[3] MVCL/MTV	OPTIMIZATION RANK MVCL/MTV
1	S02	Outside light controls	0.1	1.3	13.7	0	20	644 29.9	15	5.4 11.7	1 1
2	S06	Grill Fan shut-off	0.0	-0.0	0.9	250.4	20	712 30.7	15	1.3 1.6	2 2
3	S05	Night setback	-0.0	-0.0	0.1	280.1	20	680 25.3	15	1.2 1.2	3 3
4	S04	DHW Heat[5] recovery	0.1	0.6	6.1	0	100	3,500 29.1	15	0.5 1.0	 4
5	S07	Double glazing	0.0	0.0	1.9	409.2	0	3,766 26.4	25		
6	S01	HPS outside lights	0.2	1.2	10.5	0	0	12,991 29.8	15		
7	S03	Economizer ignition	0.0	0.0	1.9	0	0	3,639 25.0	15		

1 Energy savings per year compared to the modified base case by implementing the given strategy. Negative savings indicate an increase in consumption.
2 Capital cost determined by converting present cost to 1983 dollars using an escalation factor of 3.5%.
3 Benefit to cost ratio. Strategy is cost effective if B/C ratio is greater than one.
First entries indicate MCLV energy savings and B/C; second entries indicate same for MTV.
4 High pressure sodium lighting sources.
5 Domestic hot water.

PRIORITIZED LIST OF ENERGY CONSERVATION STRATEGIES - MVCL and MTV

Restaurant #2

Order	ID	STRATEGY	ELECTRICAL[1] CONSUMPTION/SAVINGS-MWH PEAK	INTERM	BASE	GAS SAVINGS THERMS	O&M($)	CAPITAL COSTS[2] (83$)/ (MILL/KWH)	PROJECT LIFE (YR)	B/C[3] MVCL/TV	OPTIMIZATION RANK MVCL/MTV
1	S03	Reduce outside air	0.0	0.0	0.0	1276.3	0	150 42.5	5	50.2 50.4	1
2	S06	Range hood modifications	0.0	0.0	-1.1	6827.8	40	18,088 25.6	20	2.1 2.1	2 2
3	S05	Walk-in strip curtain	0.1	0.4	3.0	0.0	60	326 29.8	10	1.2 2.5	3 3
4	S01	Retrofit outside lights	0.4	1.4	13.9	0.0	30	5,360 30.7	10	1.2	4
5	S02	Double glazing	0.0	0.0	-0.2	889.3	0	10,530 26.5	25		
6	S04	Refrigeration heat reclaim	0.0	0.0	0.0	573.5	100	4,500 0	15		

1 Energy savings per year compared to the modified base case by implementing the given strategy. Negative savings indicate an increase in consumption.

2 Capital cost determined by converting present cost to 1983 dollars using an escalation factor of 3.5%.

3 Benefit to cost ratio. Strategy is cost effective if B/C ratio is greater than one.
First entries indicate MCLV energy savings and B/C; second entries indicate same for MTV.

Appendix C

Participation Agreement

SEATTLE CITY LIGHT

COMMERCIAL BUILDING CONSERVATION PROJECT

PARTICIPATION AGREEMENT

The undersigned The City of Seattle, City Light Department ("City Light") under partial funding from the Bonneville Power Administration hereby offers the undersigned owner or contract purchaser, ______________________________, ("Participant") up to $ ______________________________ (______________ dollars) in return for the participant's agreement to purchase and install certain conservation improvements on the terms and conditions specified in this agreement. Participant agrees to complete the financing, install the conservation measures and implement the operation and maintenance measures specified in Attachments A and B in the building(s) on the property located at: ______________________________, ("the premises").

AGREEMENTS

City Light and Participant agree as follows:

1. OWNERSHIP. Participant affirms either (a) that he/she is the owner or contract purchaser or has the lawful authority to make statements herein on behalf of the owner or contract purchaser of the premises, or (b) that he/she is the lawful tenant of the premises and that he has the right to initiate and authorize the installation of conservation measures on the premises and has written documentation verifying this right.

2. CONSERVATION MEASURES. Participant agrees to purchase and install the conservation measures on the premises in accord with the provisions set out in Attachments A and B. Participant further agrees to implement all operation and maintenance (O & M) measures specified in Attachments A and B. The Participant agrees to complete installations by ______________, 1985 and implement O & M measures by ______________, 1985. The Participant further agrees to continue performing all specified O & M measures for at least one year thereafter.

3. INSTALLATION. City Light agrees to provide the Participant with design criteria for the conservation measures listed in Attachment A. The purchase and installation of the conservation measures in accord with the criteria shall be completed by the Participant through contracts or directly through the Participant's staff. The Participant agrees to award contracts or arrange to begin work with its own staff by ________________, 1985. Following installation, Participant agrees to arrange for the timely repair, replacement or correction of any defects or deficiencies in the materials or installation at no cost to City Light within one year from the date of installation.

The purchase and installation of the conservation measures by an outside contractor are to be provided under a separate contract between Participant and the contractor. City Light shall not be, and shall not be deemed to be, a party to any such contract. All obligations to any contractor shall be Participant's and not City Light's responsibility. Participant shall be responsible for paying all obligations to its contractors.

Participant expressly acknowledges that City Light's involvement with respect to the conservation measures, including but not limited to any energy analysis, criteria or inspection by City Light of the premises or the conservation measures, is solely undertaken in connection with furnishing the funding and establishing the design criteria. The methods of installation and timing thereof, and any warranties with respect to the conservation measures or their installation at the premises are solely matters to be agreed upon between Participant and its contractors. City Light has not and does not make (and Participant acknowledges that City Light does not make) any implied or express warranty (including but not limited to any implied warranty of merchantibility of fitness) representation or promise with respect to either (a) the conservation measures, (b) any materials and labor required for the installation of the conservation measures, or (c) the installation of the conservation measures.

The estimate of energy savings made by City Light in connection with the conservation measures in Attachment A is based on typical and normal conditions including, but not limited to, climate, construction of premises, and operation of appliances, lighting and equipment. City Light has not and does not make any warranty or promise that installation of the conservation measures at any particular location will, in fact, produce such estimated saving in energy consumption at the premises.

4. INSPECTION. Participant agrees to allow authorized representatives of City Light to verify the conservation measures installed and the O & M measures implemented throughout the first year after installation and implementing such measures. City Light's initial inspection shall take place within fourteen (14) calendar days of completion of the installation and implementation by the Participant.

5. PAYMENT. City Light will provide the Participant an amount equal to ninety percent (90%) of the actual cost of purchasing and installing the conservations measures listed in Attachment A in return for the Participant's agreement to install the conservation measures in accord with the terms of this agreement, provided that the amount provided by City Light does not exceed the sum of $_________________ . In the event the projected installed costs as indicated by contractor or Participant staff proposals or bids exceed the estimated costs specified on Attachment A, this agreement may be amended in such a manner that the Participant's expense does not exceed ten (10) percent of the estimated costs specified in Attachment A.

Upon completion of the installation the Participant shall submit to City Light all receipts of purchase and installation. Payment to the Participant shall be made payable by City Light Fund warrant after City Light's assessment and verification of the installation of conservation measures and the implementation of the operation and maintenance measures.

6. RELEASE. Participant releases City Light from any and all claims, losses, harm, costs, liabilities, damages and expenses directly or indirectly resulting from or in connection with (a) the conservation measures, (b) any materials and labor required for the installation of the conservation measures, or (c) installation of the conservation measures.

7. DATA. Participant agrees to permit City Light to (a) continue to gather energy consumption data through the computerized monitoring system currently attached to the premise's energy system. Participant understands that data obtained through this project will be utilized and published in a City Light research report. City Light will not use customer's name without permission. In consideration for the cooperation herein the Participant shall be provided a summary report of the monitoring results concerning the premises at the conclusion of this portion of the study.

8. AMENDMENTS. If either party to this agreement desires a change in the items specified in this agreement, such as, but not limited to, the conservation measures listed in Attachment A, or the amount provided by City Light after the design criteria are written or contract bids received, this agreement may be amended. The changes shall be the subject of a separate written agreement.

PARTICIPANT

By ______________________________

Title ______________________________

Address ______________________________

Date ______________________________

CITY LIGHT

By ______________________________

Title ______________________________

Date ______________________________

CBCP

ATTACHMENT A

COMMERCIAL BUILDING CONSERVATION PROJECT

PARTICIPATION STATEMENT

I. The Participant agrees to implement and continue performing the following operation and maintenance measures:

Operation and Maintenance Measures

1.

2.

3.

4.

II. The Participant agrees to the purchase and installation at the premises of the following conservation measures at the following costs:

Conservation Measures	Estimated Cost of Conservation Measures
1.	
2.	
3.	
4.	
5.	
6.	
7.	
TOTAL (Including Sales tax rate of _____%)	______________

The maximum amount provided by City Light shall be 90 percent of the actual costs, or ________________________________ dollars, whichever is less.

The above referenced operation and maintenance measures and the conservation measures are more fully described in Attachment B.

Attachment B contains the narratives for the measures listed above.