LBNL-38868
UC-1600

CONF-9403277--Exc.

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Guidelines for Sustainable Building Design: Recommendations from the Presidio of San Francisco Energy Efficiency Design Charrette

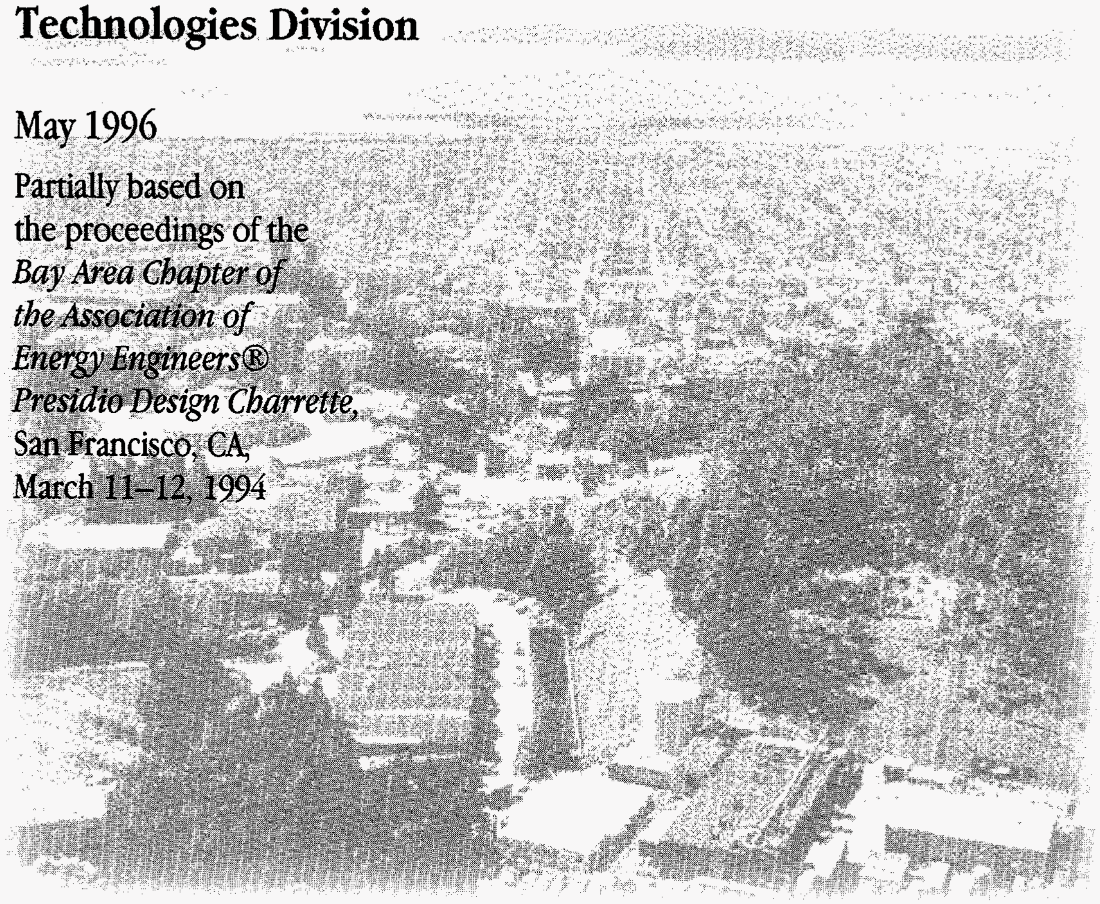
K. Brown, D. Sartor, S. Greenberg,
T. Voong, D. Lockhart, D. Kincy,
S. Wentworth, T. Riley, D. Chamberlin,
B. Hines, J.P. Waltz, and F.W. Mayhew

MASTER

Environmental Energy Technologies Division

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

ph



May 1996

Partially based on
the proceedings of the
Bay Area Chapter of
the Association of
Energy Engineers®
Presidio Design Charrette,
San Francisco, CA,
March 11–12, 1994

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or The Regents of the University of California.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE Contractors
from the Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (615) 576-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, VA 22161

Ernest Orlando Lawrence Berkeley National Laboratory
is an equal opportunity employer.

LBNL-38868
May 1996

Guidelines for Sustainable Building Design: Recommendations from the Presidio of San Francisco Energy Efficiency Design Charrette

Karl Brown
California Institute for Energy Efficiency
University of California
Environmental Energy Technologies Division
Ernest Orlando Lawrence Berkeley National Laboratory
Berkeley, CA

Dale Sartor
Applications Team
Environmental Energy Technologies Division
Ernest Orlando Lawrence Berkeley National Laboratory
University of California
Berkeley, CA

Steve Greenberg, Tai Voong, Doug Lockhart, Dennis Kincy
In-House Energy Management, Facilities Department
Operations Division
Ernest Orlando Lawrence Berkeley National Laboratory
University of California
Berkeley, CA

Scott Wentworth
City of Oakland
Oakland, CA

Thomas Riley, Doug Chamberlin
Bentley Company
Walnut Creek, CA

Brian Hines
North Coast Solar Resources
Santa Rosa, CA

James P. Waltz
Energy Resources Associates
Livermore, CA

Frank W. Mayhew
EC/TC Consulting
Sebastapol, CA

This work was supported by the Association of Energy Engineers®, the Bay Area Chapter of the Association of Energy Engineers®, and the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Federal Energy Management Programs of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098. Publication of the results of this work does not imply endorsement of or agreement with these findings by these organizations, by the Pacific Gas & Electric Co., or by the U.S. Department of the Interior, National Park Service.

TABLE OF CONTENTS

Abstract iv

Guide to the Reader v

1. INTRODUCTION 1

1.1 The Association of Energy Engineers® Design Charrette 1

1.2. The Need for Guidelines 6

1.3. Immediate Synergy with the Work of the Applications Team 6

1.4. The Intended Impact 6

1.5. Beyond the Presidio 7

2. THE CHARRETTE: ORGANIZATION 8

2.1. The Committees 8

2.2 The Event 8

3. THE CHARRETTE: MEASUREMENT AND MONITORING 10

3.1. Measurement and Monitoring Background 10
- 3.1.1. Methodology for Data Collection 10
- 3.1.2. Monitoring Equipment 10

3.2. MONITORING RESULTS 11

3.2.1. Electricity 11

3.2.2. Natural Gas 14

4. THE CHARRETTE: MODELING 18

4.1. Excessive Gas Use 20

4.2. The Impact of Air Conditioning 20

4.3. Sensitivity to Weather Data Input 21

5. GUIDELINES: ARCHITECTURAL/ENVELOPE 22

5.1. Programming Use of Space **24**
5.1.1. Inherent Benefits of Historic Buildings 24
5.1.2. Building 102 Lends Itself to Obvious Zoning of Uses 24
5.1.3. Managing Heat and Pollutant Sources 25
5.1.4. Task Conditioning and Lighting 25
5.1.5. Other Programming Issues and Opportunities 25

5.2. Envelope **26**
5.2.1. Interior Radiation Barrier 26
5.2.2. Weatherstripping 26
5.2.3. Building Insulation 26
5.2.4. Solar Collectors and Daylighting 26
5.2.5. Thermal Mass 26
5.2.6. "Cool" Roofs & Walls 27
5.2.7. Window Treatment 27

5.3. Interior Spaces **27**
5.3.1. Color Selection 27
5.3.2. Daylighting 27
5.3.3. Materials and Finishes 28

5.4. Building Ventilation and Air Circulation Systems **28**

5.5. Landscaping **29**

6. GUIDELINES: LIGHTING 30

6.1. Context—The Unique Importance of Lighting **30**
6.1.1. A Major Component of Commercial Building Energy Use 30
6.1.2. The Case for Total Lighting System Upgrade in Renovation 30

6.2. Lighting Design Criteria **31**
6.2.1. General Performance Targets—Lighting Power Density 31
6.2.2. Providing Lighting Quality 31
6.2.3. Historic/Architectural Considerations 32
6.2.4. Maintenance Economy as a Design Criteria—The Importance of Lamp Life 33

6.3. Lighting Design **33**
6.3.1. The Importance of the Design Process and Design Integration 33
6.3.2. Interactions Between Design, Commissioning, Operations, and Maintenance 34
6.3.3. Basic Notes on Specifying Sources and Fixtures 35
6.3.4. Switching/Circuiting 36
6.3.5. Notes on a Few Unique Applications 36
6.3.6. Prescriptive Notes on a Few Important Technologies 37

6.4. Automatic Lighting Controls 38
6.4.1. Occupancy Controls 38
6.4.2. Lighting Level Controls—Automatic Daylighting and Lumen Maintenance Strategies 39

6.5. Information and Design Resources for Lighting 39

7. GUIDELINES: HVAC AND CONTROLS 40

7.1. HVAC Design Criteria 40
7.1.1. Indoor Environmental Conditions 40
7.1.2. Internal Loads 42
7.1.3. Envelope Loads 42
7.1.4. Programming of Interior Spaces 43

7.2. HVAC Design Data 44
7.2.1. Designing in the San Francisco Bay Area: Climate Variability 45
7.2.2. Potential Errors in Design and Analysis 45
7.2.3. The Extraordinary Coastal Climate 45
7.2.4. Implications for Design 46
7.2.5. Specific Recommendations 46

7.3. HVAC Design 47
7.3.1. Comfort With Ventilative Cooling 47
7.3.2. Conventional Approaches 48
7.3.3. Consensus-Preferred Approach for the Presidio 48
7.3.4. Fall-back Approaches 49
7.3.5. The Importance of Integrated Design 49
7.3.6. The Importance of Commissioning 49

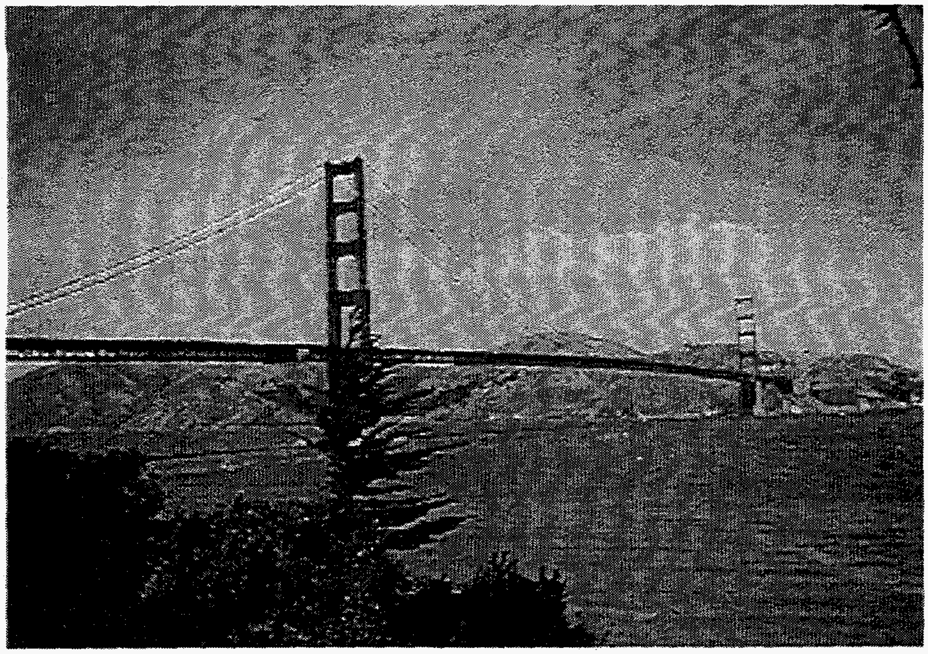
7.4. HVAC/Temperature Controls 50
7.4.1. Basic Control Requirements 50
7.4.2. Special Notes on Commissioning 52
7.4.3. Remote Operations, Monitoring and Tracking 52
7.4.4. Building Lifecycle Information: Feedback to the Design Process 52

8. ACKNOWLEDGMENTS AND DISCLAIMER 53

9. REFERENCES 54

APPENDIX A: Key to Energy Efficiency Recommendations in "Guidelines for Rehabilitating Buildings at the Presidio of San Francisco" (NPS 1995)

APPENDIX B: Steering Committee/Charrette Committee Chairs



View of Golden Gate Bridge from the San Francisco Presidio

ABSTRACT

In 1994, the Bay Area Chapter of the Association of Energy Engineers® organized a two-day design charrette for energy-efficient redevelopment of buildings by the National Park Service (NPS) at the Presidio of San Francisco. This event brought together engineers, researchers, architects, government officials, and students in a participatory environment to apply their experience to create guidelines for the sustainable redesign of Presidio buildings.

The venue for the charrette was a representative barracks building located at the Main Post of the Presidio. Examination of this building allowed for the development of design recommendations, both for the building and for the remainder of the facilities. The charrette was organized into a committee structure consisting of: steering, measurement and monitoring, modeling, building envelope and historic preservation (architectural), HVAC and controls, lighting, and presentation. Prior to the charrette itself, the modeling and measurement/monitoring committees developed substantial baseline data for the other committees. An integrated design approach was initiated through interaction between the committees during the charrette. Later, committee reports were cross-referenced to emphasize whole building design and systems integration.

This document draws on information developed in the charrette, combined with experience gained by the Lawrence Berkeley National Laboratory Applications Team in subsequent actual Presidio design assistance for the NPS. Synergism with historical preservation considerations is emphasized. We hope that this document will contribute to the sustainable development of the Presidio and provide an advanced view of facility design. The emphasis on optimization and an interdisciplinary integrated-systems approach is applicable to the creation of sustainable buildings in any setting.

GUIDE TO THE READER

Section 1 provides background information for the energy efficiency design charrette and design guidelines, while Sections 2 through 4 describe the charrette and the associated monitoring and modeling processes. These sections provide some of the context for the detailed guidelines in Sections 5 through 7. However, those interested only in the guidelines can go directly to Section 5.

The guidelines are based on recommendations from the charrette, ideas from the reference "Guidelines for Rehabilitating Buildings at the Presidio of San Francisco" (NPS 1995), and knowledge gained by the Lawrence Berkeley National Laboratory Applications Team in subsequent actual Presidio design assistance for the National Park Service (NPS). A link to the NPS guidelines is provided by Appendix A, which is a summary and key to energy efficiency related recommendations in that document. The guidelines are generally oriented toward commercial occupancies, with the building studied by the charrette being a commercial space. However, many of the guidelines are also applicable to residential occupancies.

1. INTRODUCTION

The Presidio of San Francisco comprises nearly 200 years of both military and civilian architecture in an unsurpassed scenic setting. Located on 1,480 acres overlooking the Golden Gate Bridge are over 800 buildings, most of which are architecturally and historically significant. The winding roads and trails of the Presidio afford urban dwellers and visitors from around the globe an opportunity to appreciate the beauty of this unique coastal environment as well as the historical character of the structures.

The National Park Service (NPS) assumed operational authority for the Presidio in 1994 as part of the Golden Gate National Recreational Area. The Presidio is unique in many ways, especially because of its close proximity to an urban environment. The NPS has developed a comprehensive program to utilize this national treasure to the fullest potential. Critical to the success of this program will be the development of adaptive reuse plans which maintain or enhance the historical character of the buildings and site, while accommodating modern designs and uses.

The Presidio being a military installation, many of the buildings were constructed as barracks. Adaptive reuse of these barracks poses particular design issues for prospective users. The barracks were typically constructed with minimal heating, cooling, and ventilation systems, basic lighting, and limited electrical service. In addition the rest rooms are single sex and are communal in character. Further, the room dimensions are not consistent with current design standards. For each of these problems there are solutions which can be accomplished while maintaining the historical character of the Presidio. Perhaps the most vexing issues are those associated with energy use—the heating, ventilation, air-conditioning and lighting questions. The problems range from the obvious, e.g., the routing of new ventilation ducts in a manner that maintains the historical character of the structures, to the less evident, e.g., the location of mechanical equipment in a manner that does not unreasonably introduce urban mechanical noises to this setting.

1.1 THE ASSOCIATION OF ENERGY ENGINEERS® DESIGN CHARRETTE

In 1994, the Bay Area Chapter of the Association of Energy Engineers® (AEE) contacted the NPS and offered to apply their specialized experience to the Presidio's unique situation. The Chapter's goal was to stimulate further discussion and work toward solutions which would attain the NPS objectives for reuse, recreation, and sustainable development at the Presidio. To this end, the Chapter created and fostered a working group of local energy, historic resource, and architectural professionals to share ideas and expertise. Participants included seasoned senior principals of both large and small firms, researchers familiar with approaches taken with older and historic buildings throughout the world, energy professionals from governmental agencies, and students versed in the latest technologies and design concepts. This group provided an invigorating mix of ideas and solutions.

The design charrette focused on the opportunities and constraints of a representative barracks to develop general guidelines to be used as a model for the remainder of the facilities. The focal point of the charrette was Building 102 (see Figures 1-6). Constructed in 1895, and located in the Main Post area of the Presidio, the structure has been modified slightly over the years and now contains National Park Service offices and a visitor's center.

Figure 1. Elevation, Building 102

DRAFT

Building 102 - ENLISTED MENS BARRACKS WITH MESS HALL

Photo Here

Location:
Montgomery St.
NPS Planning Area:
Main Post

Date of Construction:
1895
Historic Structure:
Yes
Listed on the National Register:
No

Historic Use:
INSTITUTIONAL HOUSING (MILITARY)
Current Use:
GOVERNMENT OFFICE

View from the Northeast *July 1992*

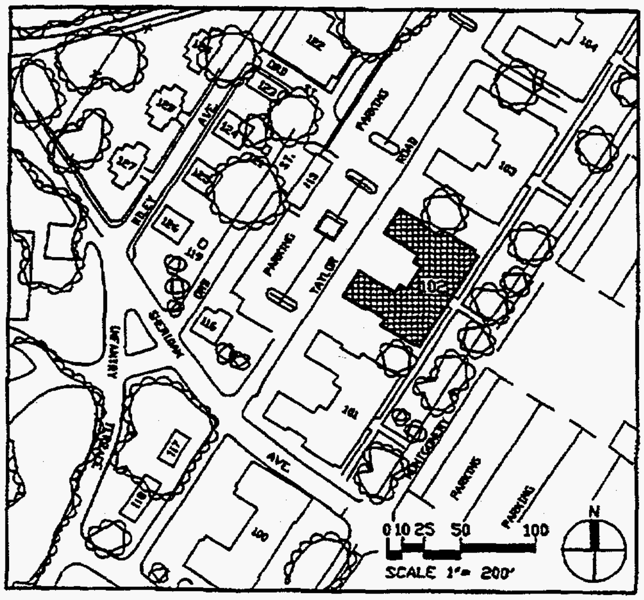
Occupancy Classification:

Hazard Level:
ORDINARY
Construction Type:
Type III

Gross Floor Areas/Ceiling Hts.:

Attic	11,975 gsf±	8'-0"
Second Floor	11,975 gsf±	12'-0"
First Floor	11,975 gsf±	12'-0"
Basement	6,324 gsf±	8'-5"
Total	42,249 gsf	

Building Significance:



Location Map *February 1993*

This fact sheet is presented as a brief synopsis of the information currently available for this building as of 08/11/93. For additional information pertaining to this building or its planning area, refer to the building file and the Presidio General Managment Plan.

Building Fact Sheet

Figure 2. Building Fact Sheet for Building 102

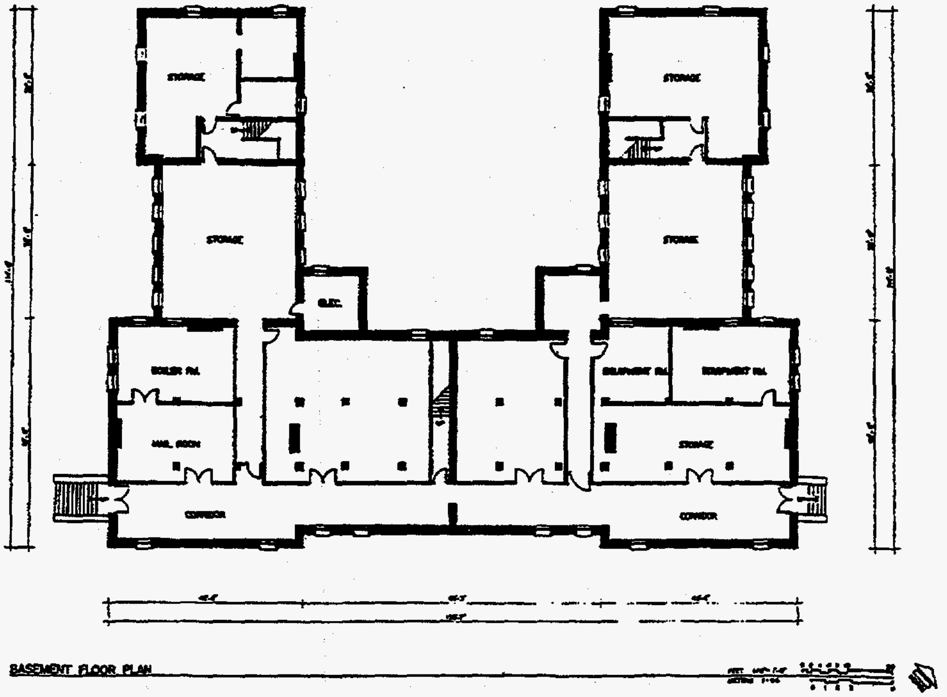


Figure 3. Building 102--Basement Floor Plan

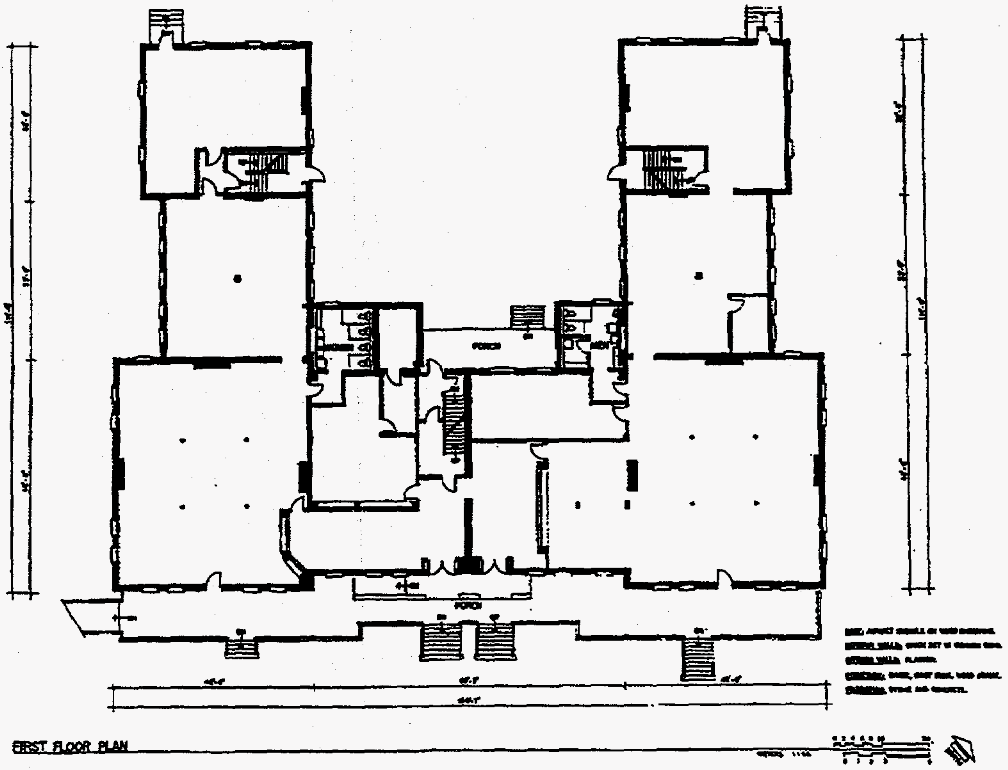


Figure 4. Building 102--First Floor Plan

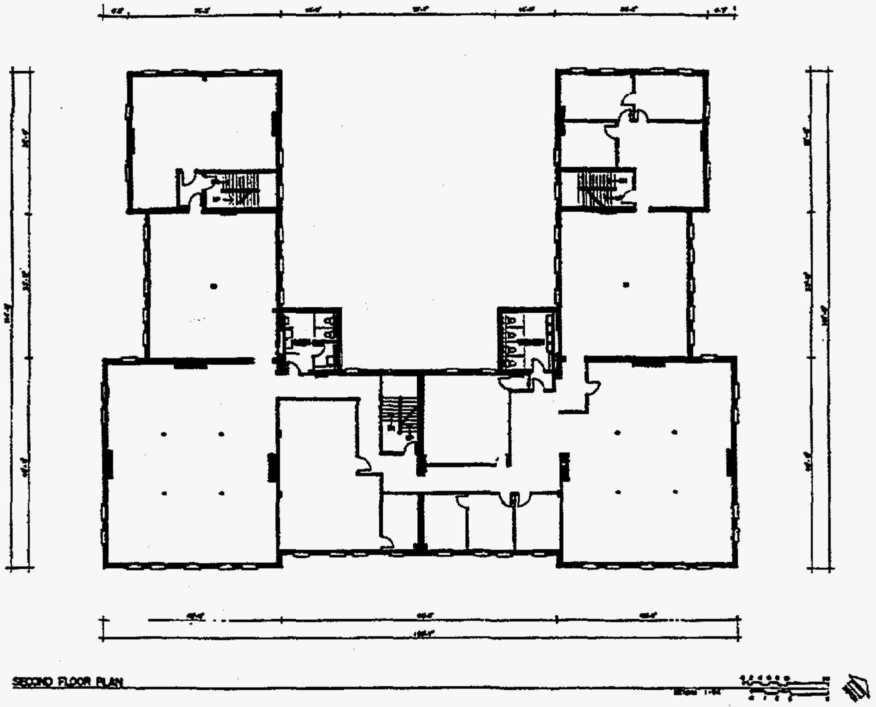


Figure 5. Building 102--Second Floor Plan

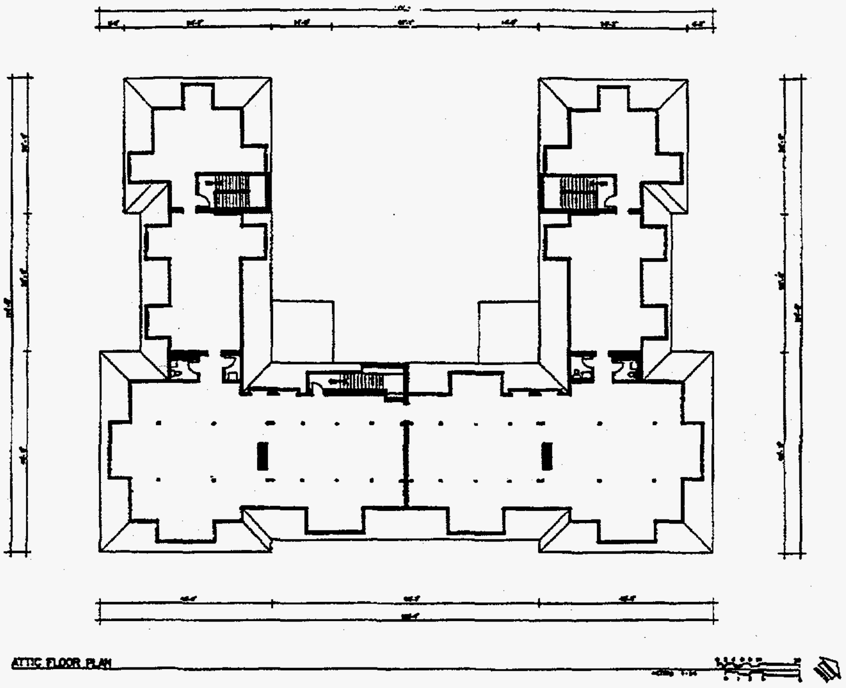


Figure 6. Building 102--Attic Floor Plan

1.2. THE NEED FOR GUIDELINES

This document uses the charrette as a starting point for the presentation of guidelines for energy efficient building design. Since the charrette, NPS personnel and others involved with redevelopment of the Presidio have expressed a substantial level of interest in using this information.

Jim Christensen, the Presidio Energy Manager, has indicated that there is an opportunity for integrating the information from the charrette report with the NPS design guides (see Appendix A, NPS 1993, NPS 1995), combining the information with other sustainable design considerations. Among the applications for sustainable design guidelines are as a reference in defining lease requirements, and as an illustration of how to go beyond standard practice and the minimum requirements of codes and standards.

Michael Giller, NPS Architectural Engineer, has indicated that the documentation of the charrette could be used as a reference for professionals working for the Park Service. He points out that the resulting guidelines can assist the NPS in meeting the requirements of the Energy Policy Act (EPACT) and Executive Order 12902 (Energy Efficiency and Water Conservation at Federal Facilities).

1.3. IMMEDIATE SYNERGY WITH THE WORK OF THE APPLICATIONS TEAM

At this writing, the NPS is already benefiting from the charrette through the Lawrence Berkeley National Laboratory Applications Team (A-Team). Funded by the U.S. Department of Energy's Federal Energy Management Program, charrette participants from the A-Team are assisting the NPS with surveys, design assistance, and design review for Presidio facilities. In particular, the work that was done in conjunction with the charrette to establish accurate design conditions has already had an impact on some of the restoration designs. The guidelines in this document build on the inspiration of the charrette with knowledge gained from actual work on Presidio buildings.

1.4. THE INTENDED IMPACT

We anticipate that this document will contribute greatly to the sustainable development of the Presidio by providing an unprecedented level of design guidance to professionals working on the many projects in the park. In addition to being a compendium of available technology and high-performance design approaches, this report provides an advanced view of facility design which emphasizes optimization instead of over sizing, an interdisciplinary integrated systems approach with interaction between the phases of design, and the quality of the resulting indoor environment.

This unique perspective will greatly assist the National Park Service not only in decreasing the operation costs and environmental impact, but in lowering first costs for energy using systems. Thus, available resources will be freed-up to be used in the creation of a better park.

These guidelines are oriented toward design teams working for progressive tenants. Such organizations are typical of the potential occupants at the Presidio. An example is the request by the Tides Foundation facility design teams for advice on sustainable design and typical energy systems load data for Presidio buildings.

In addition to the direct effects of its valuable information and perspectives, this report is anticipated to also serve as a rallying point for sustainable design efforts. As a reference for top managers and politicians; it is an example of a model effort and a focus for commitment by all parties involved in development efforts. Interactions with Presidio officials indicate that top managers will use the document when communicating with utility representatives, government officials, community groups, and others, about the benefits of a sustainable design approach. This approach includes interactions with both energy professionals and others not normally concerned with energy services.

1.5. BEYOND THE PRESIDIO

We also hope that the impact of the charrette and subsequent efforts go far beyond the Presidio. This report can be a prototype for design guidance documents that are sorely needed by facility managers, project managers, architects, and owners of facilities who want the most efficient use of their limited resources for both construction and operation.

This report will likely be replicated for other venues partly because it provides a fresh view of integrated climate-specific design. Progressive design professionals who want to create site-specific systems can seek inspiration in this example. This perspective is especially needed to stem the indiscriminate proliferation of extreme climate HVAC designs which can be both wasteful and insensitive to occupant preferences when used in the San Francisco Bay Area and other mild climate locations (e.g., inoperable windows for typical office applications).

The size and scope of the redevelopment effort at the Presidio will involve a substantial fraction of the design community in Northern California. Because of the interest of the NPS, this document may be referenced by a large number of professionals who will have the opportunity to use the advanced concepts in their other work. The potential impact of the charrette could thus include the advancement of the energy service design professions as a whole.

2. THE CHARRETTE: ORGANIZATION

2.1. THE COMMITTEES

Several expert committees were planned to undertake the various activities and design disciplines envisioned for the charrette:

- Measurement and Monitoring
- Modeling
- Building Envelope and Historical Preservation (Architectural)
- HVAC and Controls
- Lighting
- Presentation

Chairs were identified for each committee, followed by the recruiting of 5-15 professionals per group with organization according to personal interest and expertise. A steering committee was comprised of the expert committee chairs and the event organizers. See Appendix B for a list of committee chairs and other significant contributors to the charrette.

2.2 THE EVENT

The charrette was held on March 11 and 12 of 1994. On Friday, March 11, the various committees and other interested parties (about 60 in all) met in front of Building 102 and took turns touring the facility. The HVAC systems, lighting, and envelope were observed as well as the use of the facility. After the tour, the AEE Chapter met at the Officer's Club for dinner, a discussion on the findings of the measurement and modeling committees, and to hear talks by Brian O'Neill, General Superintendent of the Golden Gate National Recreation Area; and Art Rosenfeld, U.S. Department of Energy, Senior Advisor for Energy Efficiency and former head of the Center for Building Science at the Lawrence Berkeley National Laboratory (LBNL)

On Saturday, March 12, the actual design charrette took place at the Pacific Gas and Electric Energy Center. The steering committee presented an overview of the design process with specific instructions for each group. After this introduction, Steve Farnoth of the Building Envelope and Historical Preservation Committee discussed some of the issues for historical preservation.

According to Mr. Farnoth, the key to the success of the project would be in designing Energy Efficiency Measures (EEMs) which do not limit use of the facility in the long run, yet would achieve sizable reductions in energy use. He stressed that preservation of the facility was not a limiting constraint, but one of several elements that had to be taken into account during the design process. His basic guideline was: "What is left we want to preserve, what is in bad shape we want to restore, what is failing we want to replace in kind."

Next, a brainstorming effort was led by Dale Sartor, Chair of the Building Envelope and Historical Preservation Committee—to start the design process and to identify as many EEMs as possible. Dozens of potential EEMs were volunteered from the group ranging from the simple to the extremely complex. The charrette participants also discussed an integrated, systems-oriented and optimizing design approach as key to the design of a high performance, efficient, and sustainable building.

The lists of EEMs were then distributed to the design committees. These groups prioritized the measures in an effort to focus on those with the highest energy saving potential. Rough estimates of costs, savings, and payback periods were discussed as well as the interaction between the measures, systems approaches, and optimization in design.

For facilities similar to Building 102, the charrette committees estimated an approximate 50% reduction in both lighting and plug load energy use from appropriate measures. These estimates are based on expert opinion about best practices and economic viability, not on an analysis of a specific set of measures. Many of the potential measures have a fast return on investment or even an equal or lower first cost. However, life-cycle costs or long-term economics (i.e., 20 year pay back period) are the assumption for the overall potential estimate and for the charrette discussion in general. For the HVAC system, the consensus-preferred approach discussed by the HVAC and Controls committee could avoid an addition of as much as 30% to overall energy use from new conventional air-conditioning, while also saving on first costs for the renovation (see also 4.2—The Impact of Air Conditioning and 7.3—HVAC Design).

3. THE CHARRETTE: MEASUREMENT AND MONITORING

3.1. MEASUREMENT AND MONITORING BACKGROUND

Prior to the Design Charrette of March 1994, Building 102 was the subject of an instrumented submetering survey. The survey was conducted using portable computerized data-logging equipment. The resulting information was useful to the charrette committees for characterizing the building energy end-uses, and for assistance in identifying energy-efficiency opportunities. Data were gathered for about four months before and eight months after the charrette.

3.1.1. Methodology for Data Collection

The basic goal for the energy monitoring was to separate the energy use into the primary end uses: lighting; heating, ventilating and air conditioning (HVAC); domestic hot water (DHW); and plug load (mostly office equipment)—in order to determine areas for energy savings. The data gathered consisted of hourly averages for both gas and electricity.

Prior to data monitoring, the team reviewed the building documentation (mechanical and electrical drawings, electrical panel schedules, and equipment files), toured the building, and interviewed building occupants to determine what to measure and where to locate the data logging equipment. Since monitoring equipment was limited, the plug load end-use was determined as the difference between the total building use and the sum of the other monitored end-uses.

3.1.2. Monitoring Equipment

The survey equipment consisted of sensors for temperature and electric current, analog to digital converters, and small laptop-style field computers. The programming is custom tailored for each specific logging task. The customization includes changes for the number of channels and the type of sensor on each channel, as well as the frequency of the recording. A total of five data-logging computers were used to gather data from a total of 40 clamp-on current transducers and nine temperature sensors.

The data were gathered periodically from the field computers for spreadsheet analysis in a desktop computer. Portable power and temperature meters were used to calibrate the sensors in the field, with the building's main gas meter used as a reference to normalize data.

3.2. MONITORING RESULTS

3.2.1. ELECTRICITY

The electricity end-use breakdown for Building 102 is shown in Figure 7. Lighting and plug load dominate the total measured usage of about 165,000 kWh per year. Half of the small heating, ventilation and air conditioning (HVAC) usage is from electric baseboard heat for two offices, with the remainder from the heating hot water (HHW) pump and bathroom exhaust fans (there is no other forced ventilation). The air conditioner for the now-abandoned computer room was out of service, and the new conference room air conditioner was not yet installed.

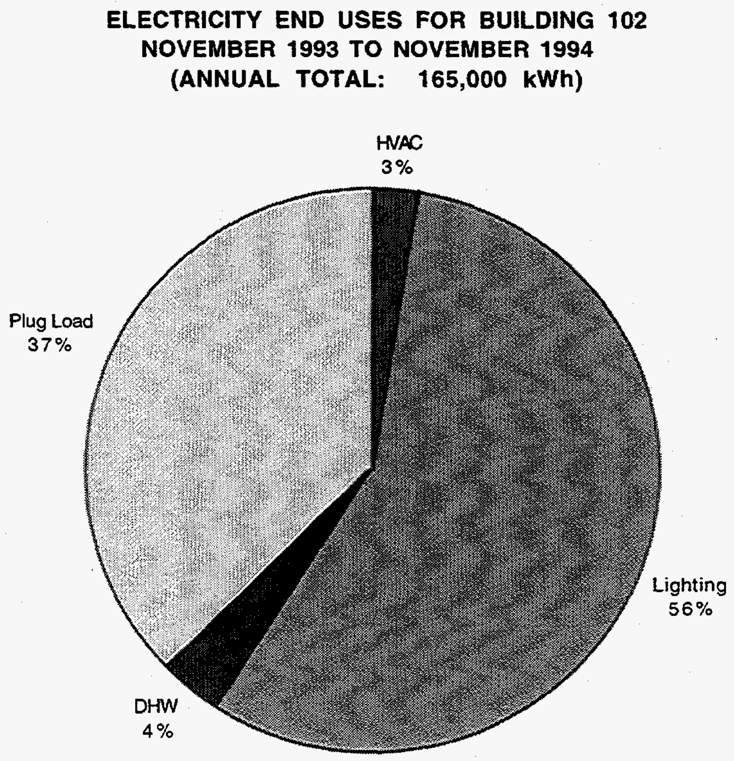

ELECTRICITY END USES FOR BUILDING 102
NOVEMBER 1993 TO NOVEMBER 1994
(ANNUAL TOTAL: 165,000 kWh)

Figure 7. Electricity end-use breakdown for Building 102.

The electricity usage for domestic hot water (DHW) consists primarily of electrical heat tracing along the DHW piping (used to keep the water in the pipes hot—there is no circulation pump or return piping). The remainder is from a small storage-type heater under the kitchen sink (the main gas-fired water heater has no electrical input).

Figure 8 shows a profile of the electric end uses over a typical week, starting at midnight on Monday morning. The building total peak is just under 45 kW, of which about 29 kW is lighting and 13 kW is plug load. The base load is about 20% of the peak. Saturday and Sunday peaks are both about 40% of the weekday peak.

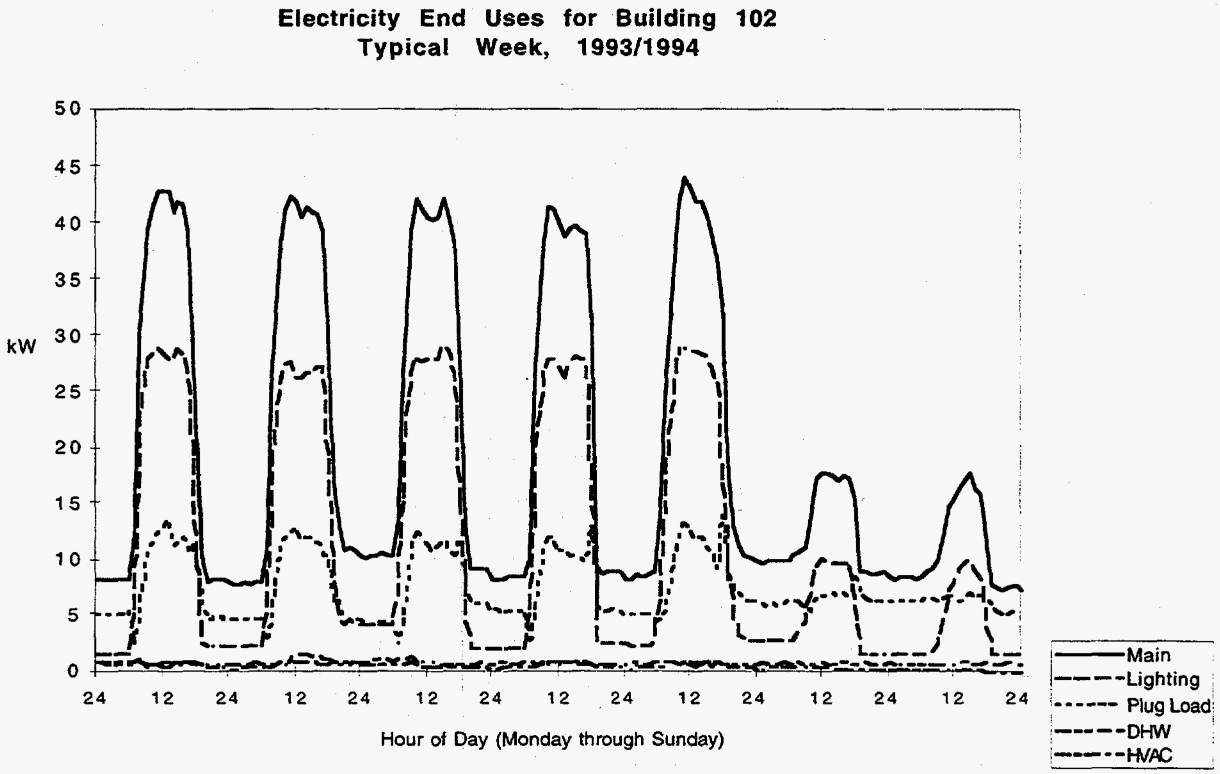


Figure 8. Electricity end-use profile for typical week, 1993-1994, for Building 102.

Figure 9 illustrates the yearly profile with a plot of daily kWh totals. Consistent with the virtual absence of air-conditioning and electric heating, there is little seasonal variation: Mid-week usage ranges from about 500 to 600 kWh/day; weekend usage ranges from about 200 to 400 kWh/day.

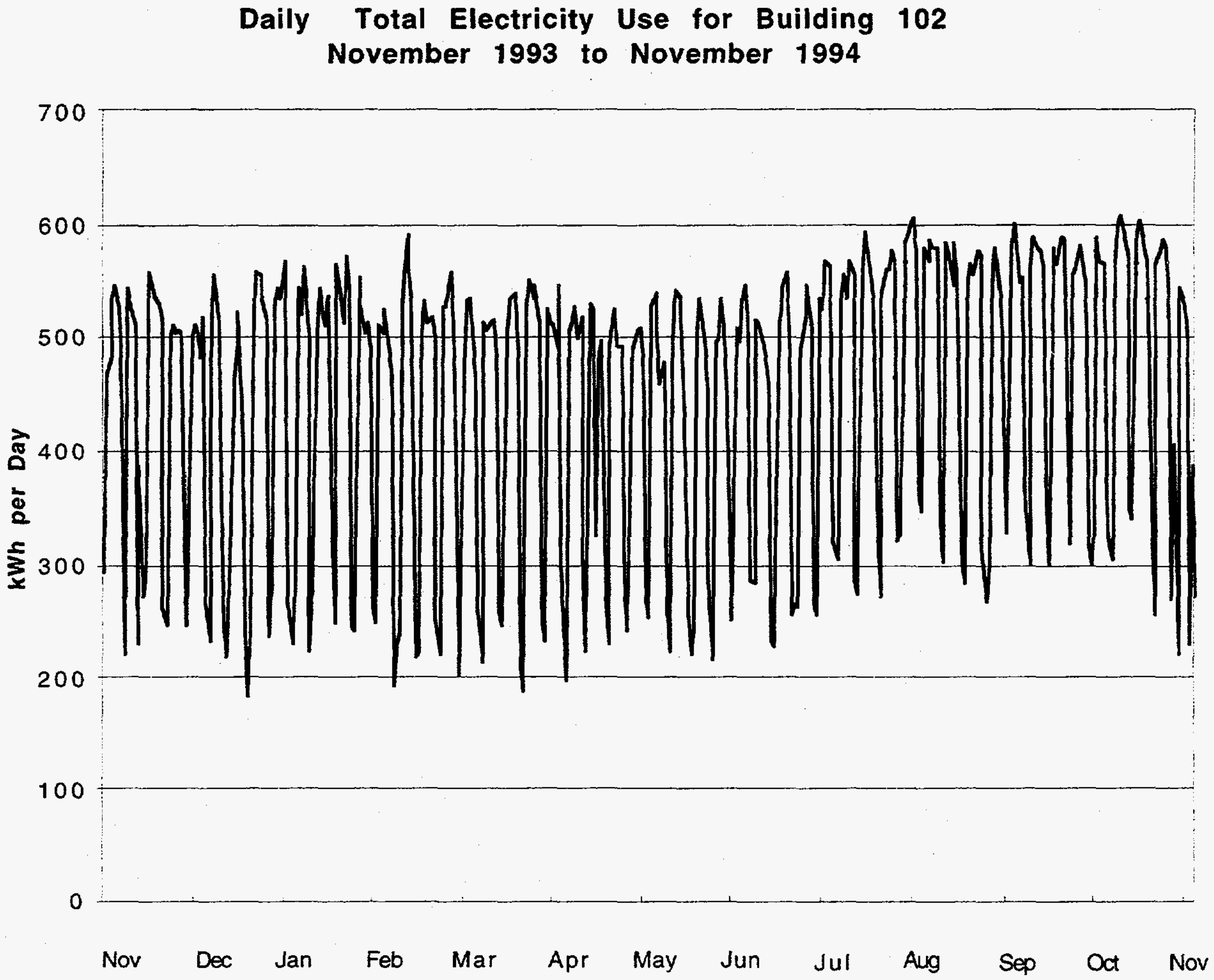


Figure 9. Electricity profile for one year, for Building 102.

3.2.2. NATURAL GAS

The actual measured gas end-use breakdown is illustrated in Figure 10. Space heating used 98% of the total 11,600 therms.

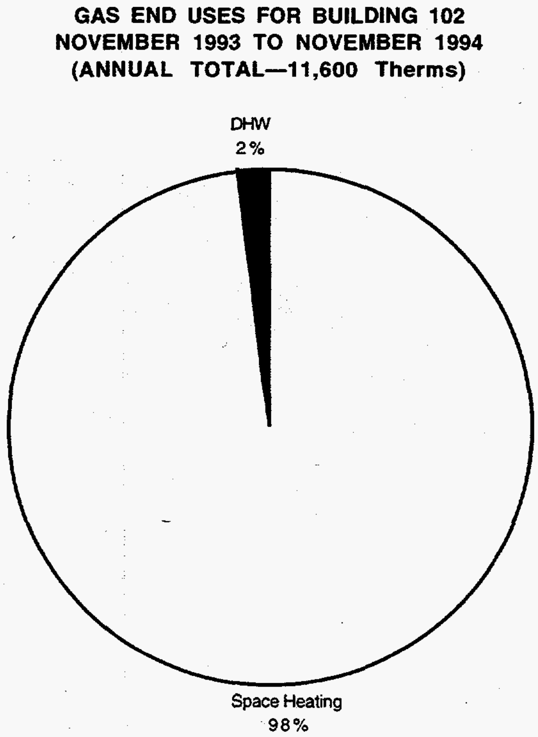


Figure 10. Gas end uses, for Building 102.

Figure 11 shows the measured gas usage over the monitoring period as a plot of daily therm totals. During the initial monitoring in November 1993, it was determined that the boiler circulation pump had failed resulting in near zero usage. After the pump was repaired, the usage was 40-55 therms per day with little variation up to the time of the charrette in March.

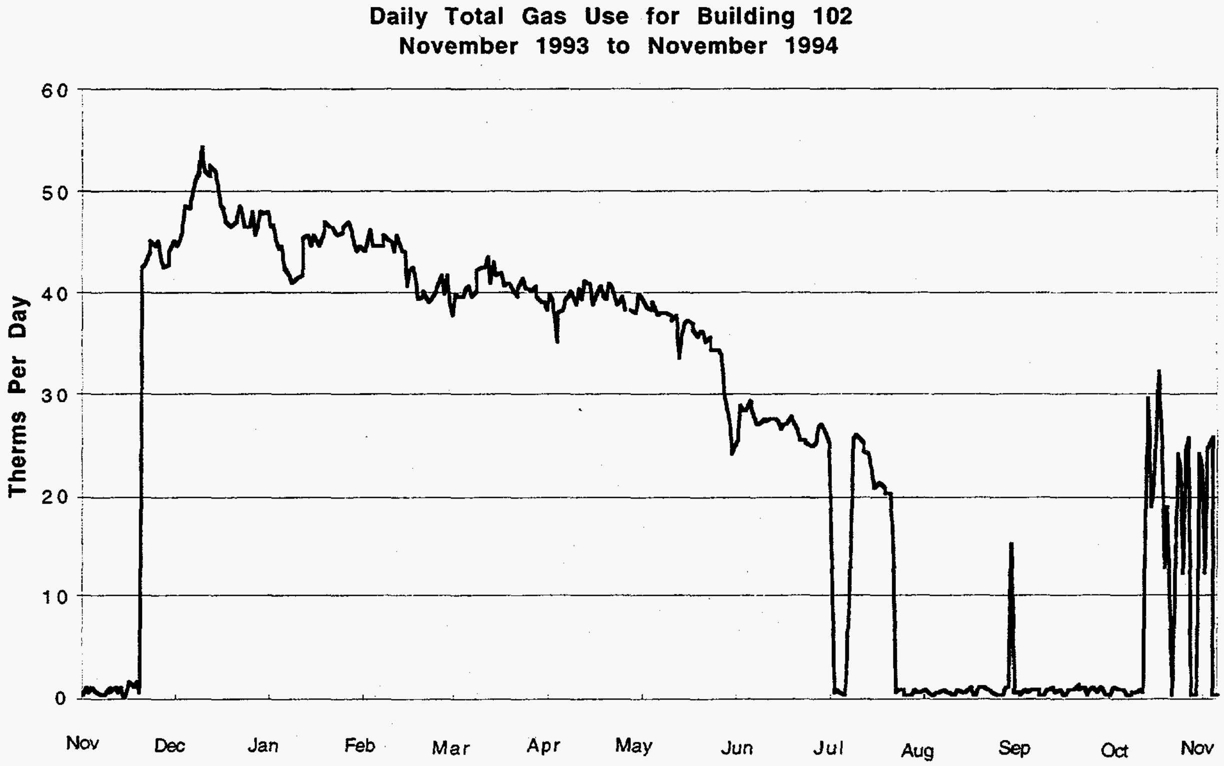


Figure 11. Gas usage, daily totals, November 1993 to November 1994, Building 102.

Figure 12 is a scatter plot of boiler gas use for December through February, as a function of outside air temperature. Note that the slope of the accompanying regression line is shallow, indicating that the boiler runs when there is little or no heating needed. This would suggest high standby losses, malfunctioning controls, and/or failed open thermostatic valves at the convectors. At the time of the charrette, the annual usage was estimated at 16,000 therms using an extrapolation of December through February data based on heating degree-days.

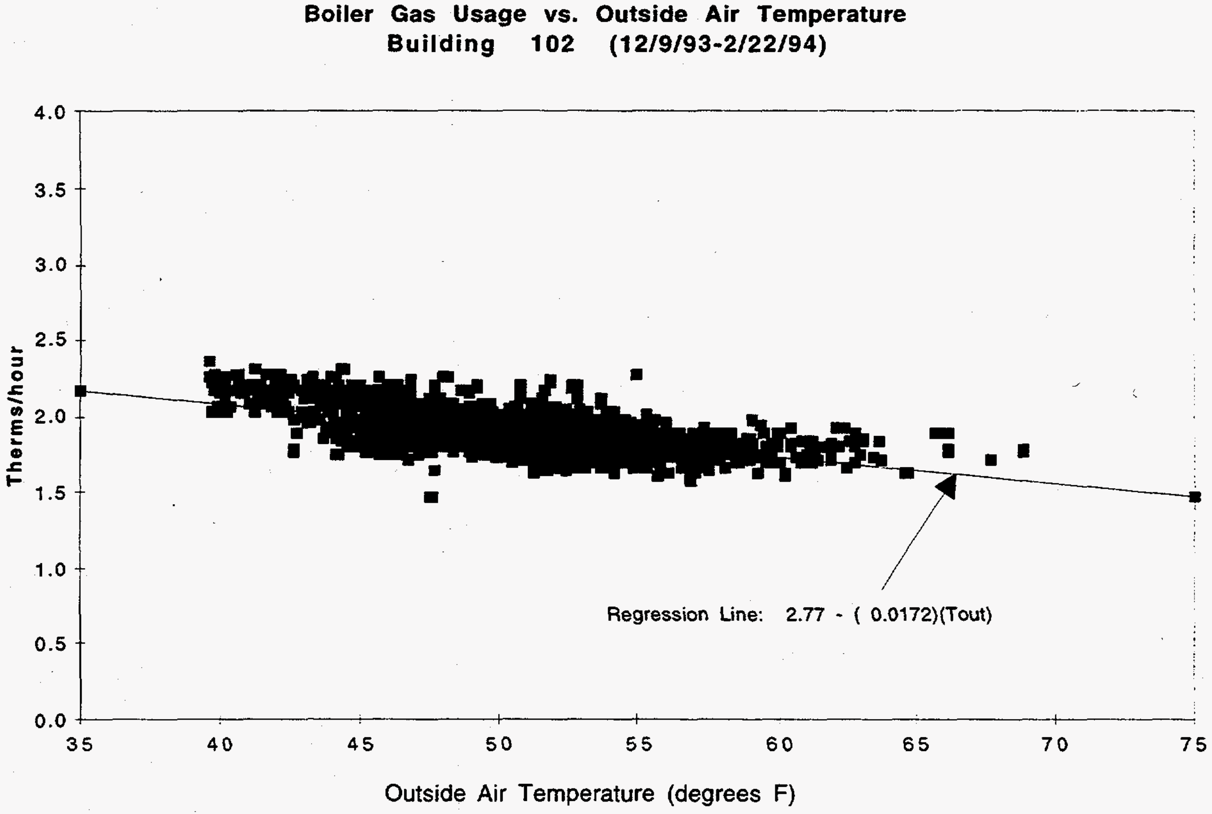

Boiler Gas Usage vs. Outside Air Temperature
Building 102 (12/9/93-2/22/94)

Figure 12. Temperature dependence of boiler gas usage, December through February, Building 102. *Note: The end points of the regression line (35 and 75 °F) are artifacts of the graph, and are not data points.*

This usage pattern continued into July when some off-time began to be observed for the boiler (indicated by hours with no usage at all). Further examination of hourly data indicates periods of time clock, temperature lockout, and extended manual shutdown modes of control from mid-July through October. Data from this period is presented in Figure 13. Not directly illustrated by the scatter plot is the larger number of zero usage points at higher outside air temperatures. Another heating degree-day based extrapolation using the mid-July through October data very roughly indicates an annual usage of 4,000 therms. See Section 4.1—Excessive Gas Use for discussion of related modeling results.

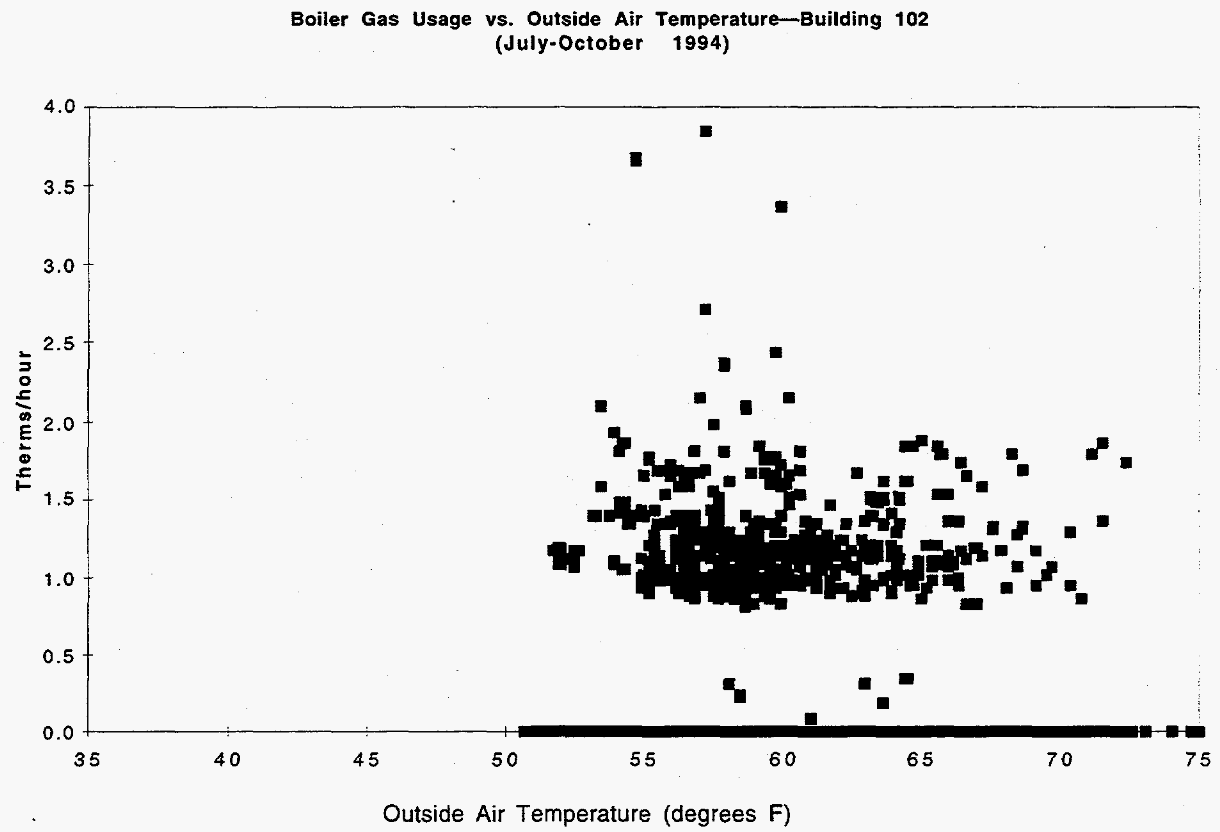


Figure 13. Temperature difference of boiler gas usage,
July through October, Building 102.

The unreferenced building information summary on file in the Presidio Project Office indicates that "typical historic" gas usage is 16,600 therms per year with a 1,000 to 1,600 therm per month seasonal range. Unverified gas metering records indicate total gas usage of approximately 16,000 therms per year for 1990 and 1991, with only moderate seasonal variation. This provides some confirmation that the operating condition observed at the time of the charrette is not atypical. The same records indicate reduced usage in the spring of 1992, making that year's total only 12,000 therms. Partial records for 1993 indicate a return to the usage pattern of 1990-91. Building 102 at the San Francisco Presidio houses the park headquarters. Prior to the AEE Presidio Charrette of March 1994, the building was the subject of an instrumented submetering survey. The survey was conducted using portable computerized data logging equipment, the results of which are discussed below and were used for characterizing the building energy end uses in order to assist in identifying energy efficiency opportunities in the building.

4. THE CHARRETTE: MODELING

The modeling committee collected information on the building and its energy-using systems from site visits and examination of the building plans prior to the charrette. This information was combined with input from the Measurement and Lighting Committees to produce a model of the building (see Figures 14-16). The model was created in DOE 2.1D with the Comply 24/DOE-24 software developed by Gabel-Dodd and Associates. Because of the limited nature of the modeling effort, no definitive quantitative assessment of redesign features was obtained. However, several important issues were illuminated by the process.

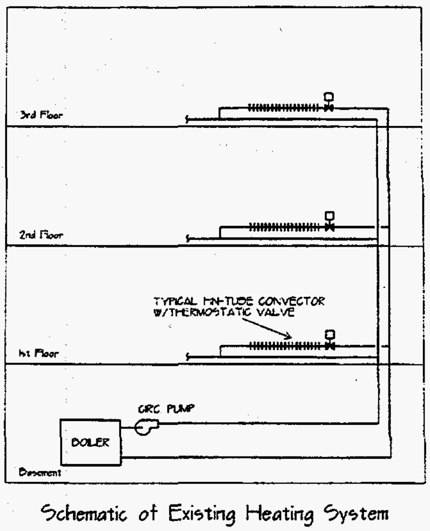


Figure 14. Schematic of existing heating system.

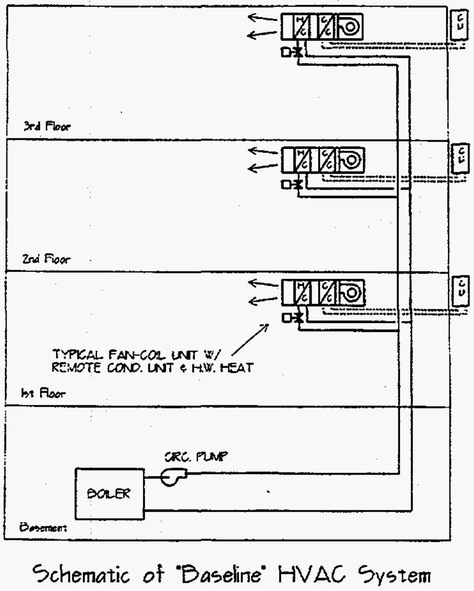
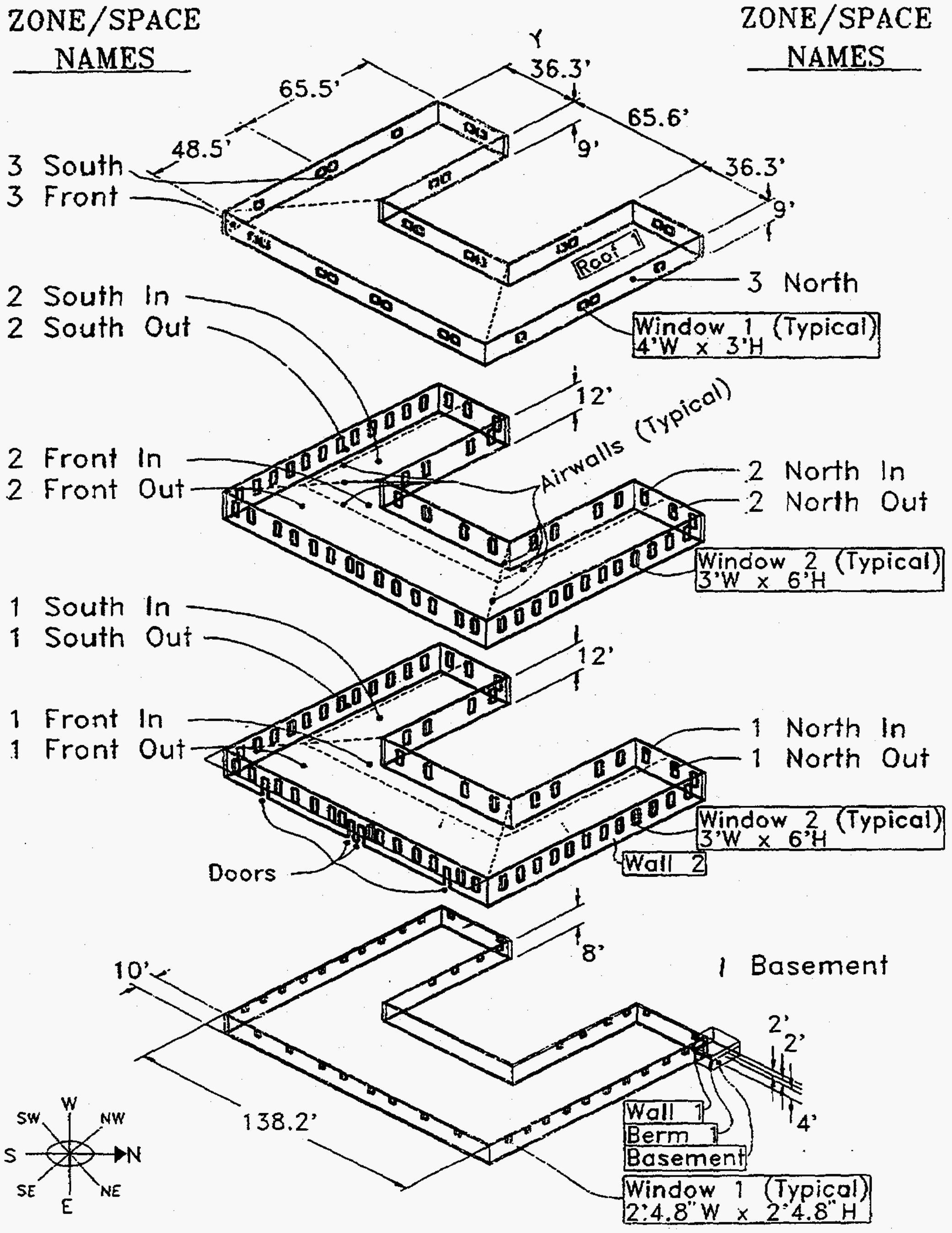


Figure 15. Schematic of "baseline" ("conventional") HVAC system.



Building 102

Figure 16. Building 102 model illustration.

4.1. EXCESSIVE GAS USE

The model could not account for the high gas energy use that is thought to be associated with the "run-away" boiler observed during the charrette (see 3.2—Monitoring Results). Annual heating boiler usage of about 16,000 therms was projected by extrapolating the measured data from the period up to the charrette based on heating degree-days. This estimated annual usage is roughly consistent with unconfirmed gas meter records (see 3.2—Monitoring Results).

The observed excessive level of use could only be modeled using around-the-clock operation and indoor temperature setpoints set much higher than is realistic (i.e. 85° F). This level of use is 2-3 three times higher than the 6,000 therms per year which the model indicated would be used by a well controlled system heating the building to 75° F. One hypothesis about the high boiler gas use is that broken controls prevented heating units from being turned off during unoccupied periods or during warm weather—with occupants modulating temperatures by opening windows.

The monitored pattern of excessive usage continued into July, when some off-time began to be observed for the boiler (indicated by hours with no usage at all). From mid-July through October, hourly usage data indicates that inconsistent modes of control were employed including extended manual shutdown, time clock, and outside-air lockout. An extrapolation based on the measured data for the mid-July through October period very roughly indicates annual heating boiler usage of usage of about 4,000 therms. This is somewhat less than the modeled usage for a well-controlled system with an indoor setpoint of 75° F.

We speculate that the partial and irregular control of the boiler resulted in control of energy use, but relatively poor comfort. Modeled usage with a (perhaps higher than typical) 75° F indoor setpoint is probably slightly higher than optimally achievable energy use. So, actual usage might be further reduced below the modeled 6,000 therm per year level.

On the other hand, the lower usage resulting from the irregular boiler control was likely accompanied by a reduction in comfort from lack of heat during unscheduled occupancy or during marginal weather conditions. This discomfort is in addition to that which may result from the hypothetical broken thermostats and lack of direct local control. A potential conclusion is that robust controls at both the boiler and zone levels are necessary for optimum comfort and energy performance.

4.2. THE IMPACT OF AIR CONDITIONING

The model indicated that building electricity use might be increased by 20-30% by the installation and operation of a forced air heating, ventilation and air conditioning system, the "conventional" or "baseline" option discussed by the HVAC committee (see 7.3.2—Conventional Approaches). This is primarily due to the increased fan energy required by the conventional system over the existing natural ventilation and cooling system.

4.3. SENSITIVITY TO WEATHER DATA INPUT

The cooling energy estimate and associated design requirements are very sensitive to the weather data used. The weather data initially used was from California Zone-3 (San Francisco Bay Area). This is the zone in which the Presidio is officially located. Additional simulations were performed using Zone-1 data (Northern California Coastal Area). Though erring on the cool side, this data may be closer to reality for summer in the Presidio than the Zone 3 data.

The estimated required cooling hours for the building using Zone-3 data is approximately five times the cooling hours associated with Zone-1 data (see also 7.2.2—Potential Errors in Design and Analysis). For the Presidio, an analysis of the requirement for air-conditioning is thus heavily dependent on the choice of design data used.

5. GUIDELINES: ARCHITECTURAL/ENVELOPE

The architectural committee dealt with several interrelated aspects of the building including programming the use of the space, the building envelope, interior design, ventilation, and landscaping. Renderings from the charrette are provided in Figures 17 through 19 as illustrations of the process--not necessarily as definitive reccomendations. In addition, the architectural committee took the lead in integrating historic concerns with the redesign. The goals of the architectural group in approaching the charrette were: 1) improve energy efficiency, 2) preserve historic integrity, 3) increase quality of the working environment (e.g., comfort), and 4) foster informed occupant interaction with the buildings (see also “Guiding Principles of Sustainable Design” - NPS 1993 and Appendix A).

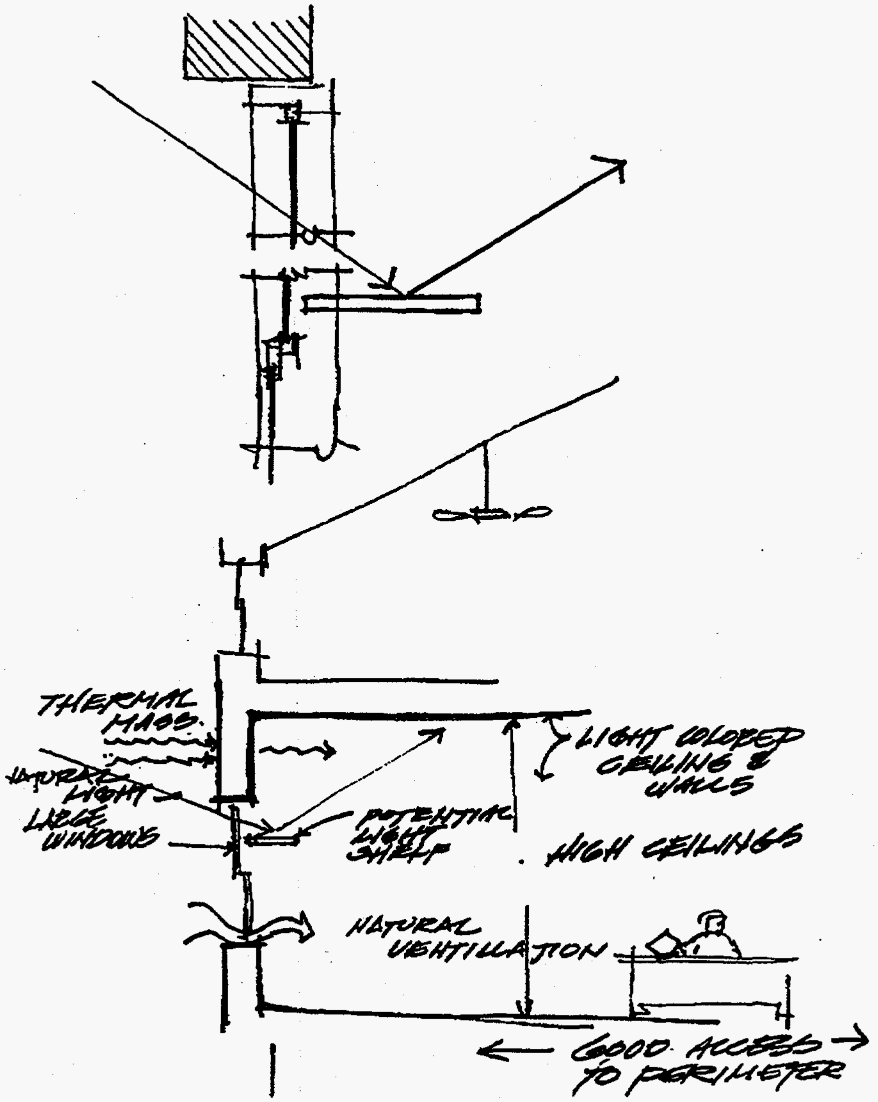
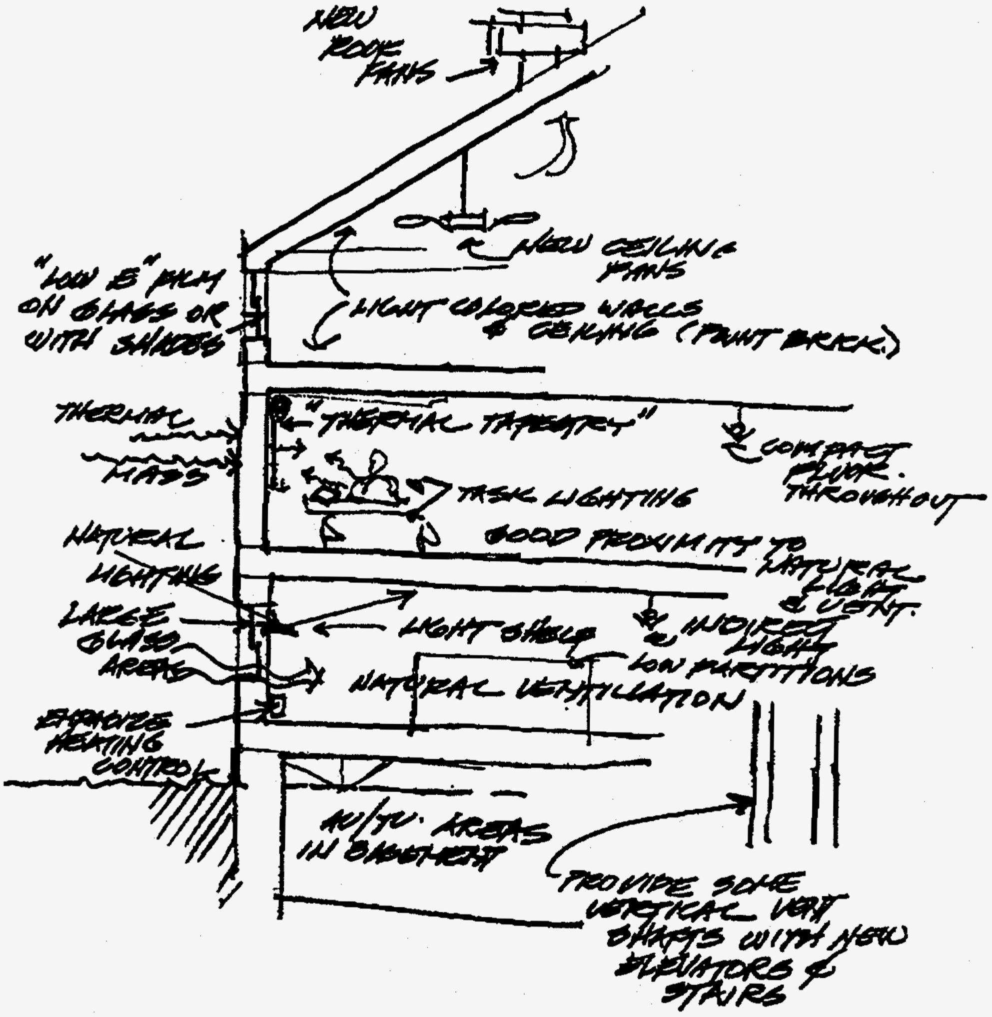


Figure 17. Charrette rendering of daylighting scheme.



J.E. BURGESS FAIA

Figure 18. Charrette rendering of HVAC scheme.

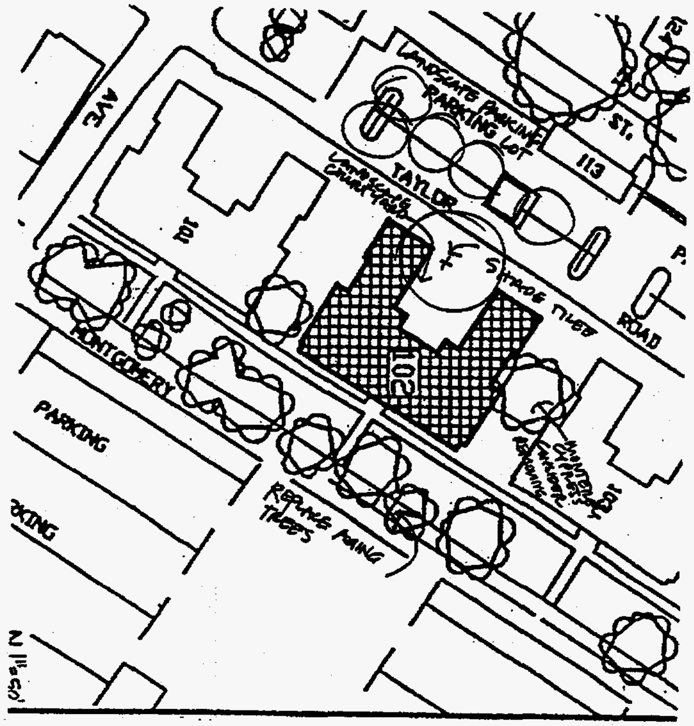


Figure 19. Charrette rendering of landscape scheme.

5.1. PROGRAMMING USE OF SPACE

Programming has to do with how space is used; it is the starting point for architectural design. The architectural committee identified a number of programming issues and opportunities during the Charrette (see also 7.1.4—Programming of Interior Spaces).

5.1.1. Inherent Benefits of Historic Buildings

The unique character and setting of Building 102 at the Presidio establishes a high market value. Major invasive changes are not necessary and are counterproductive to both energy efficiency and market value. Some of the unique features that are inherently efficient and attractive include:

- Thermal mass
- Natural light
- User operable ventilation (e.g., windows)
- High ceilings
- Minimal building depth, proximity of desks to windows
- Careful original siting for climate

5.1.2. Building 102 Lends Itself to Obvious Zoning of Uses

Open planning concepts are consistent with the original floor plan geometry as well as light and ventilation issues. It will be most advantageous to remove and limit the number of separate rooms in tenant spaces. At the same time, increased mass in basements may provide greater comfort for some applications during summer warm spells.

5.1.3. Managing Heat and Pollutant Sources

Careful planning can help to efficiently meet the ventilation and cooling needs of major heat and pollutant sources such as copiers, faxes, printers, conference rooms, and kitchens. In Building 102, installation of an elevator core will be required. This requirement might be integrated with the provision of dedicated ventilation shafts to serve such equipment and areas.

The actual plug load in Building 102 at the time of the charrette was 0.3 Watts per sq. ft. during business days and 0.1 to 0.15 Watts per sq. ft. during the night and weekends (see Figure 10). The charrette architectural committee estimated that the overall energy use by plug loads could be reduced by 50%. In general, the committee recommends that the target diversified plug load in office areas should be 0.5 Watts per sq. ft. or less. This goal can be achieved with energy efficient office equipment and equipment power management strategies (see also 7.1.2—Internal Loads and "The Guide to Energy Efficient Office Equipment" - Smith et al 1996).

5.1.4. Task Conditioning and Lighting

Occupant comfort and control over personal environment can be enhanced through the use of personal fans and task lighting. A personal fan can be a reversible feature that allows individual control over the thermal environment, while helping to avoid the installation of expensive HVAC systems having an impact on the historical character of the space (see also 7.1.1—Indoor Environmental Conditions). Task lighting is another reversible feature that can provide individual control over working conditions, while reducing the ambient lighting requirements. Reduced need for ambient lighting can reduce first costs, lessen impact on the historic character, and minimize power requirements and energy use (see also 7.1.2—Internal Loads, IESNA 1993, Eley Associates 1993). Interpretation of task/ambient designs to the occupant is important to the successful implementation of these strategies.

5.1.5. Other Programming Issues and Opportunities

Several other opportunities and issues related to programming were discussed by the committee (see also NPS 1995 and Appendix A).

- Unknown or short-term tenants dictate flexibility
- Consider use of the basement as a thermal sink
- Provide facilities to encourage alternative means of commuting to work
- Disabled accessibility
- Advanced telecommunications
- Water conserving equipment and practices
- Encourage low impact, historically sensitive, HVAC such as hot water-supplied baseboard heaters

5.2. ENVELOPE

A number of opportunities were developed relative to the architectural envelope:

5.2.1. Interior Radiation Barrier

The existing walls are masonry (low insulation/high mass). In this particular building much of the plaster has been removed exposing the red brick. The lack of insulation yields a cool radiant surface, and the dark red color absorbs light. Wall tapestries or movable fabric panels could be seasonally installed over the walls. Such a system could reduce radiant heat loss in the winter, then be removed to create more favorable conditions for summer cooling (from the standpoint of historical character, the solution is reversible). In addition, the tapestries or panels will provide an acoustic value, and their color could provide visual and lighting enhancements.

5.2.2. Weatherstripping

Weatherstripping can be applied to windows and doors to reduce drafts and control ventilation (see also 7.1.3—Envelope Loads).

5.2.3. Building Insulation

It is difficult to add insulation to historic masonry buildings, however insulation could be added to the wall areas already impacted by the addition of a "wainscot" utility chase. Insulation of attics and roofs is often appropriate (see also NPS 1995). Desirability of insulation in basements and crawl spaces is dependent on effects on summer ground coupling, with insulation potentially increasing cooling load. In this special case, the resulting need for first cost and operating expenditure for otherwise unneeded air conditioning could outweigh or negate heating season benefits.

5.2.4. Solar Collectors and Daylighting

Solar water heating and electricity producing photovoltaics may sometimes be applicable to a sustainable design, however, historic architectural considerations obviously limit appropriate locations. Maintenance must be considered on all retrofits, but for solar collectors, accessibility is an especially important issue.

Given the "fog belt" climate (see 7.2.3—The Extraordinary Coastal Climate), economic application of solar energy may be relatively limited. Daylighting may be the most applicable approach to solar design. Architectural daylighting systems already exist in many Presidio buildings which might be economically converted to provide more function. Peak use of power by this facility will likely correspond to peak demand on the electric utility during sunny periods in summer and fall, making electric lighting use avoidance through daylighting one of the most economical solar approaches at this site.

5.2.5. Thermal Mass

The thermal mass is an inherent historical quality of this building. As with building orientation and operable windows the original intent aligns with the best building performance. The optimal use of thermal mass requires the management of the heating systems to account for natural temperature differentials (wide dead band). Thermal mass should also be considered when determining the need for cooling systems (see also 7.1.1—Indoor Environmental Conditions, 7.1.2—Internal Loads).

5.2.6. "Cool" Roofs & Walls

Envelope surfaces can be selected or coated to reduce incoming heat load in summer. This strategy is most appropriate in commercial applications, where avoiding the need for expensive summer air conditioning tends to be more important than impacts on solar heating in winter.

As the appearance of many historic exterior wall and roof surfaces should not be changed, improved solar performance of these systems may depend on the use of special selective pigments which reflect solar infrared (see also 7.1.3—Envelope Loads). Some "hidden" surfaces such as flat roofs may be candidates for "white" solar reflective surfaces. In other cases, the highly functional aspects of certain historic building surfaces should be preserved, including self-ventilating barrel tile roofs and white walls (e.g., Buildings 38 and 39 at the Presidio Main Post).

5.2.7. Window Treatment

Window treatment can reduce heat gain/loss and reduce glare. Historic glass cannot be replaced, however much of the glazing is not historic glass and can be considered for replacement or modification with selective/low E films. Visibly reflective window treatments should be avoided. Storm windows reduce heat loss and drafts as well as provide acoustic benefits, however, their application to double hung windows is problematic. Insulating curtains and blinds are additional options. Any window treatment must match the existing/historic windows as closely as possible, and be sensitive to the view from the outside (see also 7.1.3—Envelope Loads).

5.3. INTERIOR SPACES

Interior design impacts energy efficiency as well as occupant comfort and productivity. Several interior design recommendations were developed:

5.3.1. Color Selection

Lighten interior spaces to improve reflectivity of ambient light and decrease the contrast (perceived glare) between the windows and the darker walls. This can be accomplished through a number of options including:

- Paint brick wall a light color
- Return to the original plaster wall
- Hang light colored wall tapestries
- Install removable acoustical wall panels (light colored)

5.3.2. Daylighting

Renovation and improvements to lighting functionality are possible for existing daylighting systems (see 6.4—Automatic Lighting Controls and 5.2.4—Solar Collectors and Daylighting). New daylighting applications such as light shelves and light pipes may also be feasible where compatible with historic preservation and architectural concerns. Daylighting goals and restoration of historic character can be achieved through removal of the dropped ceiling and return to the original higher plaster ceiling (aesthetics of this decision will be influenced by possible ceiling mounted utilities).

5.3.3. Materials and Finishes

The architectural committee also discussed the use of interior and building materials and finishes that:

- have a more benign effect on indoor air quality, e.g., low VOC paint,
- are from sustainable resources, e.g., domestic and tropical woods from certified sustainable sources,
- have recycled, preferably post-consumer, content, and are recyclable.

5.4. BUILDING VENTILATION AND AIR CIRCULATION SYSTEMS

Building 102, like many others at the Presidio, was designed to take advantage of natural ventilation through the use of numerous windows and shallow building depths. The following recommendations are intended to restore and improve the attributes of the original design (see also 7.3—HVAC Design, NPS 1995, and Appendix A):

- Maintain the use of the operable windows and transoms.
- Restore passive attic ventilation systems and through-the-attic ventilation systems (when compatible with pressure balance considerations).
- Locate rooms with special ventilation requirements together near the elevator core (see also 5.1—Programming Use of Space).
- Explore the use of operable skylights to improve daylighting and (stack) ventilation.
- Encourage the use of open office planning.
- Explore the use of ceiling fans.
- Provide task (desk) fans (see also 5.1.4—Task Conditioning and Lighting).

The Presidio project office has developed basic build-out specifications for many of the buildings. Recommended ventilation systems typically maximize the use of natural ventilation while maintaining compatibility with ASHRAE Standard 62 (see also 7.1.1—Indoor Environmental Conditions and 7.3.3—Consensus Preferred Approach for the Presidio).

The stratification of air temperature in the building (basement to third floor) can be substantial. This temperature differential combined with the building's significant mass (especially in the basement) lends itself to redistribution of the air for increased comfort and reduced energy costs. In the winter, excess heat in the third floor might be redistributed to the basement and first floor level. Conversely, during warm weather, outside air would be drawn through the basement, cooled by the thermal sink, circulated through the rest of the building, and exhausted through the third floor ceiling. Ideally this circulation would flow naturally in the cooling mode. Existing but abandoned chimneys might serve as shafts for the building's air redistribution system. These recommendations require further analysis to determine feasibility in any given building.

5.5. LANDSCAPING

Landscaping can be utilized for climate control. For example, trees can be used as windbreaks, for shading, and for evaporative cooling. Deciduous trees provide shade and filtered sun in summer months while allowing more sunlight in the winter. Large, round-headed species provide the most shade and reduce glare in front of windows. Large street trees could be planted to replace the existing trees that are aging and/or in poor health along Montgomery Street. Trees could also be planted in parking lots to shade parked cars. With the correct selection and placement of trees, the shade provided can mitigate air conditioning use (as well as provide a more aesthetic environment). The following recommendations/opportunities summarize committee discussion of other landscaping issues.

- A shrub hedge should be planted in, or along, the outer edge of courtyard space to mitigate wind and provide a more comfortable outdoor area. The bay view should be preserved.
- All planting should be compatible with the cultural landscape intent as determined by the NPS and integrated with the overall landscape plans for the Presidio.
- Irrigation can be more efficient with automatic/remote control.
- Shade for courtyard uses could be augmented by movable umbrellas until tree(s) mature.
- Site amenities such as benches should be made of sustainable materials.
- Implementation of best management practices for storm water runoff treatment and ground water recharge.

6. GUIDELINES: LIGHTING

6.1. CONTEXT—THE UNIQUE IMPORTANCE OF LIGHTING

6.1.1. A Major Component of Commercial Building Energy Use

Lighting system design is one of the most critical factors in commercial building energy performance. It can also be one of the most important aspects of creating a comfortable and productive indoor environment. Interior lighting systems typically account for a major fraction of energy use and electric demand in office-type facilities. Lighting can be an even more dominant component in the mild climates characteristic of most of California and especially the Presidio. During the Charrette monitoring period, the dominant energy end-use for Building 102 would likely have been lighting if it were not for the "run-away" heating system described in Section 3.2—Monitoring Results. The Charrette Lighting Committee estimated that the measured lighting energy use could be reduced by half with measures appropriate to Building 102.

In addition to the substantial direct energy requirements, lighting systems can also be one of the most significant heat loads for office-type spaces. In more severe climates, design of the lighting system can have a major impact on the overall cooling requirements, with substantial implications for HVAC system sizing, first costs, and operating costs. In the uniquely mild climate of the Presidio, the design of the lighting system can be the critical factor in determining the need for any "active" cooling system at all (see 7.1.2—Internal Loads).

6.1.2. The Case for Total Lighting System Upgrade in Renovation

Many lighting system renovations are limited to replacement of lighting sources or modifications to inefficient fixtures. For character defining historic fixtures, limited internal modifications are the appropriate approach (see 6.2.3—Historic/Architectural Considerations). However, a large fraction of existing fixtures at the Presidio are not historic. In these situations, fixture replacement is encouraged by Presidio rehabilitation guidelines.

Partial upgrade strategies often miss important opportunities to achieve much greater improvements in economy, as well as to substantially improve lighting quality through total upgrade of the lighting system. The extremely poor performance of many existing systems is often not fully recognized. In addition, maximum (worst case) lighting power densities from energy standards are often used as the benchmark for assessing the potential performance of new systems. Instead, the target should be the much better performance achievable through best practices.

Recent advances in source and fixture performance are substantial, with the full benefits available only though total upgrade. Potential energy savings through improved circuiting and switching may only be available with a completely new system. Finally, the full benefits of a task lighting strategy may only be achievable with a total system replacement.

We suggest always considering the total upgrade option, and taking full advantage of energy efficiency opportunities presented when the decision to do a total overhaul is driven by non-energy concerns. Non-energy concerns which can influence replace vs. retrofit decisions include:

- New light fixtures can be a relatively cost-effective way to increase aesthetic amenity of the spaces.
- New equipment means reduced maintenance requirements in the short term, and a prolonged life expectancy for the lighting fixtures, ballasts, and lamps.
- Potentially improved electrical and seismic safety.
- New fixtures can be installed according to new space uses and layout with appropriate spacing to optimize optical distribution.

6.2. LIGHTING DESIGN CRITERIA

6.2.1. General Performance Targets—Lighting Power Density

Building energy efficiency standards often establish a maximum connected lighting load per unit of floor area for various types of spaces. Lighting power density (LPD) is generally defined as the number of watts installed per square foot of floor area. For example, the allowable LPD for office buildings is 1.5 W/sq. ft. according to California Title 24 Code (Complete Building Method).

It is important to note that a lighting system using available efficient technology can surpass the performance required by Title 24 by providing quality lighting at a lower LPD. For example, an efficient lighting system can often provide quality lighting for general office spaces at an LPD of 1.0 W/sq. ft. or less, while meeting typical lighting level requirements (IESNA 1993). The LPD should be used as a tool to measure the efficiency of your design, but not as an indicator of lighting quality.

6.2.2. Providing Lighting Quality

Whether the lighting to be installed is a new system or retrofit, the issues of quality and effectiveness should be addressed. The goal of energy-efficient lighting is to produce task appropriate lighting levels and ambiance at a minimum cost.

a. Light Levels

Guidelines developed by the IESNA and other groups establish appropriate light levels for various tasks and applications. These guidelines can be used as design criteria, with interpretation best done in consultation with the owner/occupants of the space.

In retrofit applications, guidelines can be used to determine areas that are not only over lit, but also those that are under lit. Given the poor performance and design of most existing lighting systems and the major advances in performance for recent technologies, it is usually possible to provide overall improvements in lighting while also achieving major overall energy cost savings.

b. Color

Color is a major consideration in lighting quality and occupant satisfaction. Recent technical advances and increased availability of fluorescent light sources with good color have substantially improved the potential aesthetic appeal of efficient fluorescent lighting. Significantly, the Energy Policy Act prohibits the manufacture (for use in the U.S.) of some of the poorest color rendering fluorescent lamps now in common use.

With respect to light sources, the issue of color involves two primary characteristics: color temperature and color rendering. Color temperature refers to the spectrum of visible light generated by the source. Color temperature is measured in Kelvin (K). Commercial fluorescent lamps range from 2700K (typically considered warm, red) to 5000K (cool, blue). Note that common terminology produces an intuitively inconsistent rubric where higher color temperatures are referred to as "cooler" light. Those seeking to approximate daylight or provide high lighting levels for active work tasks generally prefer higher color temperatures. Those trying to match incandescent sources or create "hospitality" spaces select lower color temperatures.

Color rendering refers to how realistically a source renders the surrounding colors. Color rendering is measured by the color rendering index (CRI). A higher CRI indicates an ability to render colors closer to a reference source with overall good color distribution (CRI=100). Current technology offers fluorescent sources that provide a CRI of 75 to 90+. In comparison, a standard "cool white" fluorescent lamp affords a CRI of approximately 60.

6.2.3. Historic/Architectural Considerations

The reference "Guidelines for Rehabilitating Buildings at the Presidio of San Francisco" (NPS 1995) provides detailed information on recommended practices for rehabilitation of lighting and related systems (see also Appendix A). The guidelines encourage preserving the extensive existing daylighting. In addition, the guidelines recommend replacement of inappropriate (non-historic) lighting fixtures with energy efficient fixtures that are compatible with the historic spaces, finishes, and character. These "inappropriate" fixtures are often poorly performing fluorescent systems which can be replaced with less energy intensive options providing better lighting quality.

Though character-defining historic fixtures must be preserved, Presidio historical architects have already collaborated with lighting designers to internally rework some prominent historic lighting fixtures to use more efficient sources (i.e., high quality fluorescent). Inefficient sources are not always inherently part of the defining historic character of lighting systems at the Presidio, and can often be replaced with well-conceived retrofits.

Surface finishes, through such factors as color, hardness and reflectance, can have a significant impact on the quality of an interior environment. This effects occupant perception and mood. The texture of walls and other surfaces interacts with lighting systems which affect both esthetics and lighting quality. Maintaining character-defining surface finishes can require extra attention and some compromises with efficiency concerns.

Windows and other transparent elements (e.g., skylights, clerestories, atrial glazing) typically find favor with users because they provide connection to the outside world. Windows permit not only views but also interior illumination. Strong natural light is often a source of glare, however. The eye cannot adequately adapt to significant differences in levels of illumination which is, typically, the case when both natural and artificial light exist in the same environment. Glare and high luminance ratios may be distracting, disorienting and disabling, causing user discomfort and lowering productivity.

Both existing and new daylighting features can be effectively exploited when formulating a design approach. Crucial to the effective use of daylighting are dedicated circuiting and switching of the lighting in daylit areas, as well as shades and blinds to regulate glare and interior light levels.

Efficient sources and fixtures are available to provide accent lighting including uplight, wall wash/graze, and spot lighting for exhibits or architectural features. Fixtures which use metal halide, fluorescent, and halogen infrared sources are commonly available for all of these applications including track systems. It is important to note that standards for overall lighting power density already include allowances for these systems (see Section 6.2.1—General Performance Targets-Lighting Power Density).

6.2.4. Maintenance Economy as a Design Criteria—The Importance of Lamp Life

While fluorescent and high-intensity discharge (HID) lighting is generally promoted on the basis of energy savings, its lower maintenance cost should not be overlooked. Indeed, in many cases, labor savings resulting from an incandescent-to-fluorescent retrofit can outweigh energy savings in dollar value. Similarly, considering maintenance economy as a design criteria for complete renovations will lead to more widespread application of efficient fluorescent and HID sources.

The reason for this is the superior lamp longevity found in efficient luminaires. While most incandescent lamps have a service life ranging from 750 to 2500 hours (1000 hours is the typical life span), most fluorescent and high intensity discharge (i.e., metal halide) lamps are generally rated for 10,000+ hours of service life. LED lamps, commonly used in efficient illuminated exit signs, have an ever longer life span.

Attention to lamp/fixture interactions can further increase maintenance savings by preventing lamp life decreasing conditions like high lamp temperature, sub-optimal lamp position, or excessive vibration. Specification and implementation of appropriate maintenance for lighting systems will decrease long-term costs and improve lighting system performance.

6.3. LIGHTING DESIGN

6.3.1. The Importance of the Design Process and Design Integration

As already noted, lighting systems can be a dominant factor in defining both the quality of the interior environment and the operating efficiency of a facility. Paradoxically, lighting design does not often have a correspondingly prominent stature in the design process. Lighting design tends to be lost halfway between the architectural and electrical engineering design disciplines.

Unfortunately, qualification in either of these disciplines does not currently guarantee training, knowledge, or experience in lighting systems. Extra effort is often necessary to insure adequate lighting expertise on the design team.

Rehabilitated facilities are likely to include many complex electronic systems including power line carrier control systems, magnetic theft prevention scanners, power conditioning systems, and sensitive computer or other electronic equipment systems. Knowledge of the characteristics of modern lighting systems, particularly ubiquitous electronic ballasts and occupancy sensors, is necessary to insure compatibility among all building electrical and electronic equipment in an integrated design process.

As with the other building systems, lighting design should start with careful definition of lighting needs and constraints (see 6.2—Lighting Design Criteria). The lighting design process should be interactive with the programming and layout of spaces, design of other building systems, and planning for commissioning, operation, and maintenance of the facility.

6.3.2. Interactions Between Design, Commissioning, Operations, and Maintenance

As with all other building systems, achieving design intent for lighting is dependent on a robust commissioning process. Also, long-term performance and economy for lighting systems is dependent on proper maintenance and operations. None of these factors, with major influence on lighting performance, will come about properly unless planned for in the budgeting, programming, and design process.

Conversely, well-executed commissioning, maintenance, and operations will result in less uncertainty about lighting performance and higher maintained lighting levels throughout system life. More reliable and sustained lighting levels can be capitalized on in the design process, allowing lower "safety margins" (in particular lower lumen depreciation factors), more optimal designs, and overall lowered first costs.

a. Planning for Commissioning

Effective design will specify a robust commissioning process. The wide variety of lamp and fixture options available today often results in the wrong equipment being delivered and/or installed, with detrimental effects on lighting quality, efficiency, and occupant satisfaction. Verification of specified equipment should be included as a part of a required commissioning/construction management process. Verification of switching and circuiting, crucial to effective operations, should also be conducted in a commissioning/construction management activity. Automatic controls require special attention in the construction quality assurance commissioning process with commissioning activity planned well into the initial occupancy period of the facility.

b. Maintenance Considerations in the Design Process

Specification during design, provision for, and implementation of proper maintenance can insure sustained performance of lighting systems. Cleaning and group relamping can minimize degradation of light levels, allowing optimal designs with lower lighting power density and often lower first costs. Benefits of appropriate cleaning go beyond energy performance to include maintenance of intended appearance and aesthetics, and extended life of equipment.

Facility personnel should also be trained to monitor installed lighting controls, such as photocells, occupancy sensors, or timed systems. This equipment may need periodic cleaning or adjustments to sensitivity and timing controls to maintain peak performance.

c. Planning and Providing for Operations

Other design activities that facilitate operations can insure maximum occupant satisfaction with interior spaces. This goal should be accomplished through careful documentation of design intent; specification of labeling for switching, circuiting, and advanced controls; creation of as-builts to document the installed condition, and planning for training in operations.

6.3.3. Basic Notes on Specifying Sources and Fixtures

Many of today's fluorescent systems can be dimmed and provide accurate color rendition. Fluorescent lamps are getting smaller and are increasingly subject to optical control. Electronic ballasts are usually preferable as cost premiums are normally recouped quickly in energy cost savings (see also 6.3.6—Prescriptive Notes on a Few Important Technologies). Compact metal halide, color-corrected high pressure sodium, and halogen (especially halogen infrared) sources all have application niches for efficient indoor lighting.

Task lighting can often be used to improve quality of lighting while decreasing first costs and reducing overall lighting system energy use. Direct, semi-direct, and indirect lighting systems are all available to provide general illumination. The choice of system will be situation specific. For example, the indirect system depicted in the architectural rendering of Section V is compatible with the indirect daylighting provided by the lightshelf.

Choices will also be influenced by the experience and preferences of the designer. Indirect systems are preferred by some designers for certain applications based on lighting quality issues. Direct systems generally have a higher coefficient of utilization (CU), meaning a higher percentage of the light from the source reaches the task surface. The performance of indirect systems are more highly dependent on the reflectivity of ceiling and walls, as well as other maintenance issues.

In choosing fixtures, it is important to review photometry (distribution characteristics), as well as appearance, size, and material make up in addition to the crucial CU. Interactions between fixtures and sources are also important, especially for compact fluorescent lamps. Simple improvements in fixture design can result in significantly improved source performance, as well as increased lamp life.

a. Calculations

A variety of methods are available to calculate the light levels (illuminance) for a given space. Simple manual methods can determine overall ambient levels in simple spaces and indicate proper spacing ratios for even illumination, while sophisticated computer models can analyze more complex situations. Illuminance can be calculated as an average for a horizontal or vertical plane, or for a specific point. Illuminance levels are a function of the entire design—fixtures, ballasts, lamps, fixture locations—as well as the geometry and reflectance of the room surfaces.

b. Considering Group Relamping Strategies in Design

The light output of fluorescent and HID lamps declines significantly over time, gradually losing 10% to over 20% of their original brightness before burning out. In addition, as with incandescent sources, lamp life varies with usage patterns and from lamp to lamp, producing a chaotic burnout pattern. Planned group relamping of fixtures can take care of burnout replacement efforts in one limited period. This approach can improve overall maintenance productivity by reducing maintenance labor for relamping "set-up" and allowing "planned" instead of "demand" activities to dominate maintenance efforts. Savings in overall maintenance costs usually comfortably outweigh increases in lamp costs.

Specifying group relamping strategies during design can lead to a higher quality "product". Because lamp outputs on average never reach the low levels that occur just before burnout, designs can use lower lumen depreciation factors, lowering the overall size of the required system. This economy can be captured either in lower first costs or in higher quality equipment.

6.3.4. Switching/Circuiting

Adequate and well thought-out switching and circuiting is crucial to minimizing energy consumption and to facilitating occupant use and enjoyment of interior spaces. Building energy performance standards generally mandate multiple circuits in any space, as well as encouraging or mandating automatic controls (see Section 6.4—Automatic Lighting Controls).

Switching should generally facilitate occupant choice of lighting levels and allow separate control of areas which are daylit. Switching should also allow for selective use of spaces during partial occupancy or intermittent occupancy for cleaning and maintenance. Labeling of switching is an often neglected, but obvious way to facilitate occupant use of the space and energy conservation.

Providing an adequate number and intelligent layout of circuits is crucial to both the conscientious manual lighting operation by occupants and the immediate or eventual implementation of automatic controls as described in Section 6.4—Automatic Lighting Controls.

6.3.5. Notes on a Few Unique Applications

a. Video Display Terminals

A major lighting application in today's workplace involves areas with video display terminals (VDTs). The special considerations for this application include the need to minimize screen "glare" or veiling reflections from lighting sources. It is also desirable to provide appropriate lighting for both screen work and simultaneous hard-copy tasks. Task lighting is often the solution for these issues. Extensive discussion and recommended practices for VDT workplaces can be found in the IESNA references listed in Section 6.5—Information and Design Resources for Lighting.

b. Exit Signs

The 24-hour operation of exit signs, along with the poor performance of common incandescent sources with respect to current technology, can make exit signs one of the most effective and economical retrofits in any facility. Similarly for renovation or new construction, specification of modern exit signs using long-lasting, light-emitting diode (LED), or other efficient technology is a simple way to improve economy of facility operation and maintenance.

LED technology is available in both economical retrofit kits that simply screw into existing incandescent sockets and in new fixtures, including fixtures with new code required features. LED and other efficient exit sign light sources reduce energy use by an order of magnitude, down to less than ten watts per fixture.

6.3.6. Prescriptive Notes on a Few Important Technologies

a. T-8 Lamps

The technology of T-8 fluorescent lamps represents a significant improvement in lighting efficiency while retaining or improving existing lighting quality. The rare earth phosphor coatings usually used in T-8 lamps provide improved color rendering and lumen retention. Ease of retrofit is aided by the reuse of existing T-12 lamp medium bi-pin bases. However, the electrical characteristics of the T-8 lamp require the use of 265 ma (10^{-3} amp) ballasts instead of the 430 ma ballasts typically associated with existing T-12 lamps. Electronic ballast and T-8 lamp "systems" maximize performance advantages. Additional advantages of the T-8 lamp over the standard T-12 lamp include higher fixture efficiency for comparable systems due to smaller lamp diameter.

b. Electronic Ballasts

High-frequency electronic ballasts increase fixture efficacy, resulting in increased efficiency and lower operating costs. The electronic switching process used to provide high frequency AC output invokes less power losses than processes used by standard core-and-coil ballasts. These ballasts can also eliminate "hum" and 60 Hz cycling of the light output.

Retrofit uses of electronic ballasts are facilitated by flexibility in application. Depending on fixtures, four-lamp ballasts may reduce total quantity of ballasts required. Ballasts are available in a full range of options with respect to power input and light output. Ballast factors ranging from 0.7 to 1.1 give retrofit engineers significant options in controlling light levels and power use. Ballasts with a ballast factor greater than 1.0 produce more light at a greater efficiency by overdriving the lamp at the expense of reduced lamp life. Trade-offs are possible between numbers of lamps/fixtures and lamp life in many applications, allowing optimization in design.

c. Compact Fluorescent Lamps

The development of the compact fluorescent lamp (CFL) is a significant event in energy-efficient lighting technology. The average compact fluorescent lamp consumes one-third to one-half the energy of a comparable incandescent lamp, with up to ten times the lamp life. Lamps are available with integral ballast in a single screw-in component, as well as with pin bases for use with a screw-in or hard-wired ballast/base.

The variety of shapes and wattages available today allow the use of compact fluorescent lamps in an increased number of applications where incandescent lamps are currently employed. In addition, systems are becoming available with dimming and improved switching capability. These improvements have the promise of giving CFLs the ability to match incandescent and full size fluorescent capability in many difficult applications—such as with daylighting and time control systems. Improved ballast systems for CFLs are also improving starting characteristics and reducing problems with harmonic distortion.

6.4. AUTOMATIC LIGHTING CONTROLS

While adequate and well-planned switching and circuiting is basic, further economy in operation can be achieved through the use of automatic control systems ranging from occupancy sensors to remote switching applications to daylighting controls. These are all complex applications requiring special attention to commissioning and maintenance. Basic occupancy sensor systems are the most mature of the automatic control strategies, with some off-the-shelf solutions being practical and reliable. Remote, daylighting, and lumen maintenance controls all currently require systems integration with no turn-key solutions yet available for specification. Automatic control of electric lighting sources in daylit areas is especially dependent on careful design.

6.4.1. Occupancy Controls

a. Occupancy Sensors

Occupancy sensors reduce energy use by shutting off lights when individual rooms or areas are not occupied. The most common sensing methods are infrared and ultrasonic. Infrared sensors detect movement by sensing the difference between the emissions of heat from a human body and background space. Ultrasonic sensors are better suited to pick up activities such as writing and typing. The ultrasonic sensors provide 360° coverage, compared to 180° for the infrared sensors, covering a larger area and detecting small movements over an entire classroom or office. Some sensors incorporate both types of technology. Considerations when installing occupancy sensors include:

- Install where spaces are typically unoccupied relative to total building occupancy, such as in conference rooms, single offices, store rooms, and restrooms.
- Match sensor mounting and detection pattern with the use of the controlled space.
- Be aware of potential false triggers: HVAC ducts or other heat sources (for infrared detectors) and open windows or other air movement (for ultrasonic detectors).
- Occupancy sensor controls may not be suitable to control certain lighting systems (e.g., HID lamps, preheat and instant start ballasts, some electronic ballasts, compact fluorescent lamps; check with manufacturer).

b. Remote operations

Remote operations applications can include energy management system strategies such as lighting sweep. Implementation of these strategies requires careful planning and provision of appropriate occupant interfaces.

6.4.2. Lighting Level Controls—Automatic Daylighting and Lumen Maintenance Strategies

Automatic daylighting controls and lumen maintenance strategies both have the potential to provide significant further reductions in lighting energy operation costs. Automatic dimming of electric lighting systems when daylighting is available reduces the dependence on occupants to eliminate unnecessary electricity use, with optimized lighting levels and maximum economy. Lumen maintenance systems employ dimming systems to maintain constant light levels as lamps age and dirt or wear decreases luminaire efficiency. The excess energy use incurred by "new" or freshly cleaned systems is virtually eliminated by lumen maintenance strategies.

Both automatic daylighting control and lumen maintenance require accurate sensing of light levels on task and sophisticated control algorithms. The use of specialized expertise in designing these systems is strongly recommended. Detailed discussion of these advanced applications can be found in the Advanced Lighting Guidelines and other references (see 6.5—Information and Design Resources for Lighting).

6.5. INFORMATION AND DESIGN RESOURCES FOR LIGHTING

The following resources are available for assisting quality lighting system design at the Presidio:

Presidio Specific Reference: Guidelines for Rehabilitating Buildings at the Presidio of San Francisco (NPS 1995; especially introduction and sections on windows, interior spaces, mechanical and electrical systems, energy efficiency, health and safety concerns; see Appendix A)

Building Specific Reference: Site Assessments compiled for individual buildings by Presidio/NPS Architectural Project Managers

General Reference: Advanced Lighting Guidelines - 1993 (Eley Associates 1993; available for a nominal cost from the California Energy Commission)

General Reference: Illuminating Engineering Society of North America Lighting Handbook-Reference and Application, 8th Edition (IESNA 1993)

General Reference: IESNA Recommended Practices

Local Library: PG&E Energy Center Reference Library (includes collection of product catalogs and literature).

World Wide Web: inter.Light(tm) home page with product databases and other design resources, http://solstice.crest.org/efficiency/iris/inter.light/ (This information is provided for informational purposes only and is not intended as an endorsement.)

7. GUIDELINES: HVAC AND CONTROLS

7.1. HVAC DESIGN CRITERIA

7.1.1. Indoor Environmental Conditions

During the development of Guidelines for Rehabilitating Buildings at the Presidio of San Francisco (NPS 1995), Michael Giller, NPS Architectural Engineer made the following comments which give an indication of the needs of the client for design efforts at the Presidio:

"Existing building codes have relatively narrow comfort zones defined. As the authority having jurisdiction, the NPS needs to acknowledge the natural light, ventilation, and thermal swing of the buildings and define broader comfort zones. This administrative decision would guide design criteria to work with existing building characteristics. The rehab guidelines should discuss whether moderate late afternoon heat gain should be addressed with air conditioning or a fan. A mechanical engineer will opt for the AC unless directed otherwise."

This quote indicates that the authority having jurisdiction over the project may choose comfort guidelines other than American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 55 "Thermal Environmental Conditions for Human Occupancy" (ASHRAE 1992, 1995). However, in the event that ASHRAE Standard 55 is chosen as the design basis, the full capability of the comfort science embedded in this standard should be exercised to provide effective means to achieve comfort.

The following are aspects of comfort science recognized by ASHRAE Standard 55-1992 which can be utilized for efficient and effective provision of thermal comfort and ventilation. For more information, please see ASHRAE 55-1992 (including addendum 55a-1995) and 62-1989 "Ventilation for Acceptable Indoor Air Quality" (ASHRAE 1995, ASHRAE 1992, ASHRAE 1989).[1]

a. Operative Temperature

ASHRAE Standard 55 defines comfort in terms of operative temperature. Operative temperature is a function of dry bulb temperature and the temperature of surfaces with which the occupant exchanges thermal energy through thermal radiation (walls, ceiling, etc.). A common (but risky) practice is to make the "simplifying assumption" that the operative temperature equals dry bulb temperature. This assumption may be the source of some of the "testimonials" that the ASHRAE Standard does not accurately define comfortable conditions. If this assumption is made in establishing the proper dry bulb temperature range and the occupant is sitting close to a warm wall or window, then they could actually be outside the comfort envelope.

---

[1] For official interpretations of the Standards, correcpondence can be conducted with the respective committees through ASHRAE (ASHRAE Manager of Standards, 404/636-8400).

Conversely, if the surfaces are cool (as may occur with a large thermal mass building in a nominally cool climate) then higher dry bulb temperatures may be acceptable. Thus, careful application of the comfort science described in the Standard can maximize building performance, both improving comfort and lowering energy use.

b. Air Movement

ASHRAE Standard 55-92 allows higher operative temperatures if air movement is provided under certain prescribed conditions. The provision of small personal desk fans may allow lower energy use and the design of a less expensive HVAC system. Personal fans should be distinguished from local thermal distribution (LTD) or task air-conditioning (TAC) systems which can be relatively expensive and potentially energy intensive with performance depending heavily on design and operation.

c. Selection of Design Criteria

Summer design weather data has been commonly produced for three potential levels of exceedence: 1%, 2.5%, and 5% (see 7.2—HVAC Design Data). This value is the percentage of time that the outdoor conditions exceed the given values. These particular percentages are for four summer months (June through September), making the exceedence equivalent to approximately 29 hours, 73 hours, and 146 hours, respectively. ASHRAE is converting to an annual basis for these percentages, capturing exceedence sometimes observed in other months.

A recent addendum to ASHRAE Standard 55 clarifies that its criteria shall be met under conditions not exceeding design weather conditions (ASHRAE 1995). The intent of design weather data has been to recognize the impracticality of providing an HVAC system that can meet all loads under all conditions encountered in its lifetime. However, it is often attempted to comply with the standard approaching 100% of the time. Such a conservative interpretation can be a poor allocation of resources available to improve the working environment.

Without guidance from the owner/client, common practice has been to choose a low exceedence level, then apply large safety margins to the processes and equipment. The result is often over sizing, with the associated higher costs and inefficiency. However, an owner such as the NPS can specify a higher exceedence level, as well as ask for careful design in lieu of large safety margins.

For the conditions at the Presidio, and elsewhere in the Western U.S., this approach will affect more than the sizing of the equipment. It can also affect the system choice, increasing the potential for low-energy ventilative cooling strategies and reliance on the thermal mass.

d. Ventilation

ASHRAE Standard 62-89 allows ventilation needs to be met through natural ventilation systems in many applications, including some similar to Building 102. In a basic build-out design package, the NPS Presidio Project Office has specified operable windows as the ventilation system for large portions of Building 101 (Wallace 1996). As with the task lighting and space conditioning implementations discussed in Section 5.1.4, interpretation of the systems to the occupant will help in their success.

7.1.2. Internal Loads

Design of HVAC systems should be interactive with the architectural and lighting design. If load calculations indicate the need for substantial cooling equipment, then the rest of the building design should be reexamined to determine if systems like lighting can be improved. Also, load assumptions can be checked against similar energy-efficient buildings (see 7.4.4—Building Life-cycle Information: Feedback to the Design Process)

a. Lighting

The lighting design group identified the potential to do retrofits which could reduce the lighting load to 1 W/sq. ft. or less in normal office applications. Total lighting system replacement options could reduce lighting density to even lower levels. A total replacement of lighting, minimizing heat loads, would allow the use of very low cost ventilative cooling in more situations. The economics and interactions of all systems should be examined in making lighting decisions.

b. Plug Loads and Internal Pollutants

The Architectural Committee recommends that target plug loads in office areas be 0.5 watts per sq. ft. or less. Accomplishment of this goal can be facilitated by the use of energy-efficient office equipment (ACEEE 1996). Major office equipment, a possible source of both heat and pollution, can also be centralized with separate dedicated ventilation. The Architectural Committee also emphasized "source control" for indoor air quality as compatible with sustainable environmental concerns. This involves minimizing pollutant sources associated with office equipment and furnishings, reducing ventilation needs (see also 5.1.3—Managing Heat and Pollutant Sources).

7.1.3. Envelope Loads

a. Roof Reflectivity

Use of hematite (red) or chromium oxide (green) pigments could provide architecturally compatible roof surfaces with the high solar reflectivity (infrared) desired for summer design conditions. Note that in "commercial" spaces, heating needs will be primarily in the early morning hours. The heating penalty from reduced solar gain will thus be minimal. Tile roofs with low contact footprint and allowance for circulation of air will significantly also reduce solar gain to the building.

b. Weatherization

Weatherization measures recommended by the NPS (NPS 1995) and discussed by Architectural Committee include weather-stripping and other air sealing. These infiltration-control measures will reduce heating and cooling loads, however, infiltration control should be coordinated with the natural ventilation strategies proposed as the consensus-preferred HVAC alternative.

c. Fenestration

Restoration guidelines encourage consideration of reversible low-E and/or selective window films; and even addition of insulating panes to existing windows under certain circumstances (NPS

1995). Damaged glazing which cannot be restored can be replaced by architecturally appropriate designs. Interior shades or blinds can be coordinated with daylighting strategies.

The charrette participants initially perceived a restrictive situation with respect to the possibility of using high performance glazing. However, the "Guidelines for Rehabilitating Buildings at the Presidio of San Francisco" (NPS 1995) state the following:

"Windows admit light and air to a building. In considering sustainability, both of these functions must be maximized, but in a controlled manner. Admitting natural light to all spaces, while limiting ultraviolet radiation and excessive heat gain through the use of appropriate shading devices, is one important step. The addition of weather-stripping and regular maintenance will also increase thermal efficiency. In some individual cases, the installation of insulating or low-E glazing or glass applied film may be an appropriate energy saving device. The Presidio climate should rarely require air conditioning; well-maintained, operable windows will be an important and preferred component in creating an efficient ventilating system for most buildings. Replacement windows and components, when required, should be constructed of environmentally sound materials of the highest quality."

It appears that the guideline authors would also advocate the consideration of selective glazings and reversible (removable) films to avoid heat gain and the need for AC if they were aware of this relatively new technology. The guidelines do not flatly prohibit modifications to the windows (adding insulating panes to existing non-historic glass) when these modifications do not substantially alter their appearance. Also, where the old glazing is irreparably damaged, new high performance glazing can be considered. Finally, these guidelines indicate that the operable nature of the windows is an important historical feature to be preserved. Additional excerpts from the NPS guidelines can be found in Appendix A.

7.1.4. Programming of Interior Spaces

The layout of Building 102 makes it extremely difficult to "build-out" the interior spaces in a manner that creates core zones. The distance to an exterior wall in Building 102 is virtually always less than 25 feet. In fact, the architectural group considers the minimal distance from any desk to a perimeter wall (and windows) to be a desirable feature. To derive maximum advantage from this aspect of some Presidio buildings the Architectural Committee recommends open planning concepts and limiting the number of enclosed rooms in tenant spaces.

The "Guidelines for Rehabilitating Buildings at the Presidio of San Francisco" (NPS 1995) further indicate that: "constructing new interior walls or partitions or inserting new floors that intersect windows, damaging their historic fabric on the interior and creating a negative impact on the windows' appearance from the exterior" is not recommended.

The Architectural Committee also points out the opportunity for small-scale, non-automated, individual control of heat, light, and air. Additional architectural recommendations regarding "build-out" include: use of adjustable wall surfaces (see also 7.1.1—Indoor Environmental Conditions for discussion concerning radiation barriers and ASHRAE Standard 55), enhanced natural ventilation, use of local fans, use of vertical (building) circulation when appropriate to counter adverse stratification effects.

7.2. HVAC DESIGN DATA

Design weather data for the Presidio and other sites is shown in Table 1.

Table 1. Design Weather Data for the Presidio and Related Sites

	San Francisco Presidio**	San Francisco Airport	Oakland Airport	Oakland Navy Hospital	Arcata
Latitude (deg):	38	38	38	38	41
Elevation (ft):	20	8	6	500	218
Winter Design Data/Heating (December through February* * *)					
99% DB* (° F):	38	35	34	29	31
97.5% DB (° F):	40	38	36	32	33
Prevailing Wind:	W	S	E	NW	E
Mean Speed (knots):	5	5	5	5	5
Annual Degree-Days:	3080	3042	2909	2962	5029
Summer Design Data/Air Conditioning (June through September* * *)					
1% DB/MCWB*/WB* (° F):	74/63/64	82/64/65	85/64/66	92/66/68	68/60/62
2.5% DB/MCWB/WB (° F):	71/62/62	77/63/64	80/63/64	88/65/67	65/59/60
5% DB/MCWB/WB (° F):	69/61/61	73/62/62	75/62/63	84/64/66	63/58/59
Mean Daily Range (° F):	12	23	24	30	15
Prevailing Wind:	W	NW	WNW	NW	NW
Summer Criteria Data/Air Conditioning					
DB hrs ≥ 93 ° F:	0	2	5	29	0
DB hrs ≥ 80 ° F:	12	63	92	360	3
WB hrs ≥ 73 ° F:	0	0	0	0	0
WB hrs ≥ 67 ° F:	8	13	14	129	1

(*): DB = Dry Bulb Temperature;
MCWB = Mean Coincident Wet Bulb Temperature;
WB = Wet Bulb Temperature

(**): These are the only known design data associated with the Presidio. The reference lists the same data for several sites around the Golden Gate: Fort Baker, Fort Barry, the Presidio, Letterman Army Hospital, and Fort Mason. The data is consistent with that for other coastal sites (see also ASHRAE 1982).

(***): ASHRAE's new annual basis for design data reflects exceedence that can be observed in other months (ASHRAE 1997). Such data is not currently available for the Presidio.

Source: Facility Design and Planning: Engineering Weather Data (Air Force, Army, and Navy 1978)

7.2.1. Designing in the San Francisco Bay Area: Climate Variability

Other Bay Area sites in Table 2 are listed to illustrate the importance of careful selection of design criteria when working in the San Francisco Bay Area or California. The Bay Area has been described as having the largest temperature ranges across a given geographical distance of any location in the world. While the differences between the bay and inland areas are usually noted, this is also true around the Bay. This variation can be seen in the large indicated difference in summer design temperatures between the Presidio and the Oakland Veterans Hospital: 17°F for the typical 2.5% design condition.

7.2.2. Potential Errors in Design and Analysis

Even around San Francisco, the temperature differences are striking. As an example, the San Francisco airport temperature is 6°F warmer than indicated for the Presidio under the 2.5% design condition. In the ASHRAE 1993 Fundamentals Handbook (ASHRAE 1993), the Presidio data in Tables 1 and 2 are presented under the listing "San Francisco Co" (implying downtown). This could be a source of error in design for downtown San Francisco or the South of Market areas. In these locations the actual temperatures can be expected to be higher than for the Presidio, perhaps approaching those for the airport in some locations.

The Arcata data is presented to facilitate discussion of the proper source for hourly weather data. Though the Presidio officially falls into climate zone CTZ 3 (Oakland), use of the much warmer CTZ 3 weather tapes for analysis of the Presidio will produce significant errors. The CTZ 1 (Arcata) weather tapes, though certainly erring on the cool side, may actually be closer to reality for the summer at the Presidio. A synthesis of data for the two zones may be more appropriate for energy analysis.

7.2.3. The Extraordinary Coastal Climate

Though anyone living or working along the northern California Coast is aware of the much talked about "air conditioning" built into the climate, the uniqueness of this climate is worth some discussion. Examination of data in the above reference, as well as the ASHRAE Fundamentals Handbook, reveals the exceptional nature of the climate. These references provide design data for hundreds of locations throughout the United States, North America, and the world.

The summer design temperatures on the Northern California coastline are extraordinarily low, falling into the free cooling or ventilative cooling range (i.e., outdoor design temperatures several degrees lower than comfortable space temperatures per ASHRAE Standard 55-92). These conditions are found all the way down the Northern California coast to Pt. Arguello south of Vandenburg Air Force base. This includes Santa Cruz, Pt. Sur, and Monterey with some of the more southern locations being even cooler than the Presidio. The root source of these special conditions is the cold ocean current flowing down the coastline.

With the exception of the northern California coastline, such free cooling conditions are not found near sea level and at low latitudes in the listed data. Similar or lower design temperatures may be found only at much higher latitudes, in mid-latitudes in a marine-dominated area

(England/Scotland/Ireland, Nova Scotia/Newfoundland, New Zealand), or at high altitudes (Quito, Ecuador or Bogota, Columbia).

A sustainable facility in this climate would take advantage of these unique conditions, using ventilation as the sole cooling source in many applications. Ventilation would also be used to the greatest extent possible in other applications, with other available free cooling sources used for higher heat loads and more difficult design situations.

7.2.4. Implications for Design

The cool summer design conditions allow low cost (both first cost and operating cost) ventilative cooling strategies to be widely applied. The opportunity afforded by this unique climate can be maximized by using currently available techniques to minimize solar and internal loads. Also, many of the Presidio buildings have high thermal mass and a predominance of exterior zones (where virtually all of the floor area is proximate to the building perimeter). With these conditions, a central design goal should be use of ventilative cooling as the sole cooling source except in situations of extraordinarily high internal loads (core conference rooms and process loads).

In high load situations, the unique climate again offers low cost-free cooling options including evaporative chilling (water-side economizer) and direct (no compression cycle) ground source cooling. It should also be noted that the presence of an air-side economizer allowing 100% outside air operation could allow down-sizing of an active AC system. This is because the return air (at 78°F or more and with added moisture from occupants) will be warmer and wetter than outside air under design conditions.

7.2.5. Specific Recommendations

a. Natural Ventilation and Cooling

See Sections 5.4—Building Ventilation and Air Circulation Systems, 7.1.1—Indoor Environmental Conditions, 7.3.3—Consensus Preferred Approach, and Appendix A.

b. Forced Ventilation and Cooling

If the interior design of the building dictates forced ventilation for some areas, there appears to be ample opportunity to run vertical ducting to bring air up to the areas in need. The Architectural Committee recommended that occupancies that require forced ventilation and rooms with special mechanical requirements should be located on the courtyard side of the building to facilitate the location of vertical duct work. Pending seismic evaluation, the abandoned chimneys are also worthy of investigation for location of vertical duct runs (see also 5.4—Building Ventilation and Air Circulation Systems).

c. Mechanical Cooling

It should be emphasized that compressor-based and other energy intensive cooling should be avoided and that other alternatives exist. Primary in the discussion at the charrette was the use of indirect/direct evaporative cooling for ventilation air. Other options include indirect evaporative systems (including multi-stage), water-side economizers (evaporative chilling), and direct ground-source cooling (without refrigeration cycle).

In some cases the loads, special energy service needs, and other constraints may dictate compressor-based or other energy-intensive cooling systems. In this case, the plethora of options can be considered with an eye toward modularity (staged systems) and highest efficiency equipment. Optimized designs, careful attention to design assumptions, an integrated systems approach, and proper sizing are critical to the performance of such systems (see also 7.1—HVAC Design Criteria and 7.3—HVAC Design).

7.3. HVAC DESIGN

7.3.1. Comfort With Ventilative Cooling

A general approach to the mechanical design can be found in the Guidelines for Energy Efficient Commercial Leasing Practices prepared by the President's Commission on Environmental Quality/Alliance to Save Energy (ASE and PCEQ 1992). In this reference, mechanical systems recommendations include determining if and how much heating will be needed. For the Presidio, this approach should be extended to cooling.

From the weather data in the previous section (7.2—HVAC Design Data, Table 1), cooling design conditions are summarized in Table 2. It should be noted that additional hours of exceedence are encountered in other months (e.g. October).

Table 2.
Presidio of San Francisco Summer Design Conditions

Exceedence Level		Dry Bulb / Mean Coincident Wet Bulb / Wet Bulb
Percent (4 month basis)	Hours of Exceedence (June through September)	°F
1	29	74 / 63 / 64
2.5	73	71 / 62 / 62
5	146	69 / 61 / 61

If ASHRAE standards are used as comfort criteria and typical assumptions made about office activities in the occupied spaces, then the upper summer operative temperature boundary would be approximately 26°C (79°F) at 50% RH or slightly higher with occupant controllable air movement. With outdoor design temperatures lower than target space temperatures, there is substantial capability for ventilation air to take up the heat load.

In addition, the high thermal mass of the building will have the ability to mitigate heat load (Abrams 1986). This effect will manifest itself in two somewhat interactive ways. First, a substantial portion of heat loads can be absorbed by the thermal mass. Second, comfort is dependent on operative temperature (a function of dry bulb and temperatures of interior envelope surfaces). Heavy cool walls will mean that dry bulb temperatures corresponding to the design operative temperature will be higher than the operative temperatures. This situation can allow more heat load to be absorbed by the ventilation air.

7.3.2. Conventional Approaches

Many mechanical engineers believe that inoperable windows and a forced air system with mechanical or alternate cooling sources, universally applied to all building spaces, is always the best way to insure compliance with comfort and ventilation requirements. Much of the discussion by the HVAC and Controls Committee covered the arguments for and against this approach with some of the engineers expressing sentiment for using such a conventional system. However, the group consensus was that the design process should start with a consideration of approaches more compatible with the climate and the sustainable development goals of the facility.

7.3.3. Consensus-Preferred Approach for the Presidio

The consensus-preferred approach was the application of ventilative cooling concepts for as much of the building as possible. The desirability and feasibility of this approach is reinforced by recommendations from the Rehabilitation Guidelines (NPS 1995), Guiding Principals of Sustainable Design (NPS 1993), and the Architectural Committee (see also: 5.1—Programming Use of Space, 5.4—Building Ventilation and Air Circulation Systems, Appendix A). All recommendations indicate that natural ventilation cooling options should be emphasized where appropriate and that build-out/ programming guidelines should discourage the creation of interior zones which would require more energy-intensive cooling schemes. In particular, rehabilitation guidelines strongly indicate that the operable windows be maintained and access to the windows not be decreased by the addition of interior walls.

In addition, the costs of energy-intensive conventional systems is very high compared to the ventilative cooling approaches. Expenditure of these funds would need to be justified against other potential uses of the funds to increase the overall amenity of the spaces and productivity of the occupants (see also 7.3.5 - The Importance of an Integrated Design Approach).

The preferred approach would be to utilize natural ventilation cooling, including operable windows, to the extent that is feasible. Natural ventilation is allowed by ASHRAE Standard 62-1989. Provision of a dedicated exhaust ventilation system for high load equipment, along with careful planning of high occupancy areas like conference rooms, can maximize the situations where this approach is workable. As mentioned in Section 7.1.1—Interior Environmental Conditions, the NPS Presidio Project Office has used this approach to maximize the use of operable windows for ventilation in a basic build-out design package for Building 101 (Wallace 1996).

7.3.4. Fall-back Approaches

The next alternative to be considered is the use of forced ventilation for interior zones and higher heat load areas. This strategy includes dedicated cooling/ventilation for unavoidable high load equipment.

The use of active cooling sources is the least desirable alternative, to be used where very high heat loads are unavoidable (or when failures occur elsewhere in the integrated design process). Alternative sources, such as water-side economizers, should be given strong consideration for this approach.

For systems with compression-based or other energy intensive cooling sources, economizers are very important. In this unique climate, the economizer mode is the design or most likely condition. Outside air temperature and enthalpy are virtually always below that of return air from occupied spaces. Where active cooling is necessary, cooling of 100% outside air is usually appropriate. Economizers would modulate to provide temperature control when cooling requirements are low. They would limit outside air to minimum ventilation levels for heating, to implement a warm-up mode, or for the infrequent trans-design summer condition. Economizer damper systems require regular maintenance for reliable functionality. Alternatives include multiple mode approaches like two-speed fans or dedicated ventilation/cooling systems.

7.3.5. The Importance of Integrated Design

Because excess heat loads can trigger the need for expensive active cooling and/or forced ventilation systems, it is important to revisit design decisions in other areas (lighting, architectural, programming) to determine if higher performance in these systems can reduce the need for cooling and lower overall costs. Consideration of these interactions is good practice in any situation and crucial in the Presidio climate, where it is often possible to eliminate the need for active cooling entirely—with major associated cost savings.

"Back-of-the-envelope" cost estimates developed by the HVAC and Controls Committee indicate that the cost of the consensus-preferred approach to HVAC renovation in Building 102 would be between $100,000 and $200,000. This includes full renovation of the existing heating systems, mechanical ventilation for half of the floor area (a conservative assumption) and natural ventilation for the remaining floor area. For comparison purposes, the cost of refitting the entire building with a forced air system and air conditioning was estimated at $360,000.

7.3.6. The Importance of Commissioning

Most buildings do not work as designed. For example, in Building 102 the Measurement and Monitoring Committee initially found the HVAC Controls to be dysfunctional (see 3.2—Monitoring Results). Commissioning of HVAC and other building systems is an essential part of the rebuilding process. It helps to insure that design intent is achieved, and that building performance is maximized. Also, the building and its systems can be protected from damage or excessive maintenance requirements by appropriate commissioning. Substantial resources should be devoted to the commissioning process in the budgeting for the rehabilitation. Commissioning should be fully integrated with the design and operations phases of the building life-cycle. Several guidelines for the commissioning process exist including those produced by ASHRAE (ASHRAE 1996) the Bonneville Power Administration/U.S. DOE (PECI 1992), and the Florida Design Initiative (PECI 1996).

7.4. HVAC/TEMPERATURE CONTROLS

Applicable controls will be determined, to a large extent, by the tenant and the systems. Attention should be given to operator needs, facilitating the monitoring of system status, and maximizing the convenience for managers in tailoring operations to actual occupancies and services. Capability for remote monitoring and operation of buildings will be valuable in maintaining persistence of performance. The HVAC and Controls Committee is that a complete energy monitoring and control system (EMCS) be given special consideration in the initial building(s) to be developed. In addition to setting a precedent for facility-wide systems, it is thought that monitored performance data can be used for on-going design requirement refinement.

7.4.1. Basic Control Requirements

a. Time Clock Control

Simple "smart time clock" control can provide the most significant savings by assuring that appropriate energy-using systems are turned on and off based on simple occupancy schedules. Such systems should be integrated with status indicators and manual controls to allow operators maximum convenience in adjusting schedules. The minimum configuration should include:

- Seven-day-a-week schedules
- Holiday schedules by date
- Easy method of override to facilitate special schedules
- Battery backup

b. Zone Control

Effective zone controls can both improve comfort and reduce energy use. For hot water convector systems like those in Building 102, these can consist of either integrated self-contained valve and thermostat units; or low-voltage two-position thermostats with valves at appropriate radiators or zone feeders.

The importance of robust high-quality control equipment cannot be over emphasized for this application. Observation of the buildings at the Presidio indicated large numbers of windows opened for cooling while the hot water radiators were still active. This can be largely attributed to the fact that many of the convectors have broken controls and cannot be turned off, even in warmer weather. Operable and reliable heating controls, combined with occupant education, will go far in alleviating this situation.

Some charrette participants suggested that overuse of the operable windows during heating be addressed by interlocking the windows with the heating controls. This would consist of a magnetic or mechanical switch with a contact that opens when the window is opened. When used in conjunction with low-voltage zone thermostats, the heating could be automatically turned off when the windows are opened. However, this strategy appears to contradict the intent of ASHRAE 62- 1989 regarding the availability and use of operable windows for ventilation (see 7.1.1—Indoor Environmental Conditions and 7.3.3—Consensus Preferred Approach for the Presidio). ASHRAE 62-1989 has not been interpreted for this implementation.

c. *Heating Source Control*

With a hot water boiler as the heating source, several control strategies can be employed to achieve higher efficiencies. The two most basic strategies are (1) to place the boiler under time clock control so that it does not turn on when the building is not occupied, or is not about to be occupied, and (2) an outside air lockout that locks out the boiler when the outside air temperature is high enough that there is minimal heat loss through the exterior walls, floors, or ceilings.

When there is an actual need for heating, heat losses can be minimized by varying the temperature of the hot water proportional to the load. As the load is reduced, controls can reduce the supply temperature. This achieves two beneficial results. The first is that the losses from the hot water piping will be reduced as the temperature of the water in the pipes is reduced. The second is that the zone controls will operate with a much higher degree of accuracy as the temperature is reduced. This will limit the problem of control overshoot during lighter loads. The simplest form of hot water reset control to apply is the use of outside air temperature as the reset variable. As the outside air temperature decreases, the hot water temperature is increased.

A more sophisticated option for boiler reset would be to obtain feedback from the zone thermostats as to the heating load in the space and use that signal to control the hot water temperature.

Boiler reset controllers are available that incorporate both time clock and outdoor reset functions and logging of historic data including: ambient air temperature, heating supply water temperature, return water temperature, desired supply temperature, boiler run time, and room temperature. These data can be downloaded to a laptop computer or accessed by modem if a phone line is installed in the boiler room. Such data can be very useful in trouble-shooting boiler problems or in fine-tuning the controllers settings. Boiler run-time information also provides a means to judge savings.

d. *Special Notes on Heat Pumps*

One special consideration in application of heat pumps at the Presidio is the demand-side management (DSM) contract provision regarding fuel-switching[2]. Converting a space that is gas-heated space to an electric heat pump system can prevent realization of DSM payments for energy-efficient upgrades in the course of rehabilitation.

Another site-specific consideration in the use of heat pumps is the extraordinarily high winter design temperatures (see 7.2—HVAC Design Data). The winter design temperatures are very close to the normal cut-off for heat pump defrost cycles (40°F). The common specification of

---

[2] The DSM contract between the NPS and the local utility (PG&E) provides for payments to the NPS for measured energy savings over a ten-year period (Sartor et al 1996).

supplementary electric resistance heat strips is often primarily for provision of continuous heat during defrost cycles. The need for supplementary electric resistance heating should be carefully scrutinized in this location.

7.4.2. Special Notes on Commissioning

While robust commissioning efforts are important for all building systems, they are especially critical for controls. Resources allocated for commissioning controls will likely go farther toward providing occupant satisfaction and maintaining the buildings than would resources devoted to oversized or rarely needed systems. The high gas use in Building 102 (see Sections 3—Measurement and Monitoring and 4—Modeling) is an indicator of a system "running out of control."

7.4.3. Remote Operations, Monitoring and Tracking

The capability for remote operation, monitoring and long term tracking, useful for most building systems, is often crucial in obtaining the best performance from HVAC systems. The ability to remotely control and program HVAC systems to accomodate periodic and changing patterns of use is of great convenience to operating personnel. Effective controls can extend their ability to manage a facility and its energy use. In addition, the availability of medium to long term historic data usually leads to improved operating strategies and the ability to maintain consistent high performance of systems. The options for accomplishing this range from local systems described above for boilers, to site-wide supervisory control and data acquisition systems. The latter are often called energy management and control systems (EMCS) in buildings where they are sometimes integrated with other "building automation" functions.

7.4.4. Building Lifecycle Information: Feedback to the Design Process

An energy management and control system with capability for performance evaluation and tracking can provide information to the budgeting, programming, and design process for renovation of subsequent buildings. Such a "closing-of-the-loop" on the building lifecycle can be invaluable in achieving the design and resource optimization discussed in other sections.

8. ACKNOWLEDGMENTS AND DISCLAIMER

This work was supported by the Association of Energy Engineers®, the Bay Area Chapter of the Association of Energy Engineers®, and the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of the Federal Energy Management Program of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098. Publication of the results of this work does not imply endorsement of or agreement with these findings by these organizations, by Pacific Gas and Electric Co., or by the U.S. Department of the Interior, National Park Service.

The authors would like to thank the reviewers of this report: Jim Christensen and Michael Giller of the National Park Service; Rick Diamond and Steve Selkowitz of Lawrence Berkeley National Laboratory. We would also like to thank those who helped to organize and conduct the energy efficiency charrette and subsequent activities at the Presidio: Brian O'Neill of the National Park Service, Anne Sprunt Crawley of the U.S. Department of Energy, and Albert Thumann of the Association of Energy Engineers®. Thanks also to Rob Wallace, Gordon White, and Jim Kren of the National Park Service Presidio Project Office, who have graciously coordinated design assistance for various buildings. A special thanks to Pacific Gas and Electric Company for hosting a part of the charrette at their Energy Center.

And finally, thanks to all of the other participants in the charrette. As no record of actual attendance has been recovered, the following edited list of those who pre-registered for the event must suffice. Apologies to anyone who has been omitted.

Mike Vicenty
Greg VanMechelen
Marc A. Theobald
Charles Taberski
Thomas W. Solberg
Victoria Schomer
Art Rosenfeld
Alice Prussin
David Paoli
Meredith Owens
Gary Oto
Robert Ofseuit
Michael Morehead
Kenneth R. Moore
Annosh Mizany
Susan McKay
Hugh McDermott
Ann McCormick
Susan McComb
Rich McClure
Ben Martinez
Nathaniel C. Martin
David Lee
April Kaden
Carl Jordan
Lowell A. Holcomb
Fentriss Hill
Kristen E. Heinemeier
Michael Hauser
Gary Harbison
Karl Guttmann
Brad Gustafson
Mike Gabel
Steve Farnoth
Richard Engle
Frances Donlon
Mike Dixon
Andrea Denver
James L. Davis
Joe Cussary
Jill Cunningham
Greg Cunningham
Tamra Cihla
Sergei Buzolin
James E. Burlage
Frank Bryant
Larry Bravo
Bob Braun
Chris Barbee
Mike Anderson
Hemanta Agarwala

9. REFERENCES

ASE and PCEQ. 1992. *Guidelines for Energy Efficient Commercial Leasing Practices.* Washington D.C.: Alliance to Save Energy (202/857-0666) and Presidents Commission on Environmental Quality.

ASHRAE. 1982. *Climatic Data for Region X, ASHRAE Publication SPCDX.* Atlanta GA: American Society of Heating, Refrigeration and Air Conditioning Engineers (Golden Gate and Southern California Chapters)

ASHRAE. 1989. ANSI/ASHRAE 62-1989 (including ANSI/ASHRAE Addendum 62a-1990). *Ventilation for Acceptable Indoor Air Quality.* Atlanta GA: American Society of Heating, Refrigeration and Air Conditioning Engineers (Standards Project Committee 62-1989).

ASHRAE. 1992. ANSI/ASHRAE 55-1992, *Thermal Environmental Conditions for Human Occupancy.* Atlanta GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers (Standards Project Committee 55-1981R).

ASHRAE. 1993. Parsons, R.A., Editor. *ASHRAE Handbook, Fundamentals.* pp. 24.1-23. Atlanta GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

ASHRAE. 1995. ANSI/ASHRAE 55a-1995. *Addendum to Thermal Environmental Conditions for Human Occupancy.* Atlanta GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers (Standards Project Committee 55-1981R).

ASHRAE. 1996. ASHRAE Guideline 1-1996. *The HVAC Commissioning Process.* Atlanta GA: American Society of Heating, Refrigerating, and Air Conditioning Engineers.

ASHRAE. 1997. *ASHRAE Handbook, Fundamentals.* Atlanta GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Abrams, D.W. 1986. Low Energy Cooling, NY. Van Nostrand-Rheinhold.

Eley Associates. 1993. *Advanced Lighting Guidelines.* 1993. (Revision 1). San Francisco CA: California Energy Commission, Electric Power Research Institute, U.S. Department of Energy.

IESNA. 1993. *Lighting Handbook: Reference and Application.* New York. Illuminating Engineering Society of North America.

NPS. 1993. *Guiding Principles of Sustainable Design.* Denver CO: U.S. Department of Interior, National Park Service, Denver Service Center, Government Printing Office.

NPS. 1995. *Guidelines for Rehabilitating Buildings at the Presidio of San Francisco.* Denver CO: U.S. Department of Interior, National Park Service, Denver Service Center. NPS D-222.

PECI. 1992. *Building Commissioning Guidelines*, Second Edition. Portland OR: Portland Energy Conservation Inc., Bonneville Power Administration, U.S. Department of Energy.

PECI. 1996. *Commissioning for Better Buildings.* Miami FL: Florida Power and Light

Sartor, Diamond, Walker, Giller, Brown, and Crawley. 1996. *Designing an Environmental Showcase: The San Francisco Presidio.* In Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings, 5:209-217. Washington D.C.: American Council for an Energy-Efficient Economy.

Smith, Ledbetter, and Dandridge. 1996. (Revised) *Guide to Energy-Efficient Office Equipment.* Washington D.C.: American Council for an Energy-Efficient Economy. ISBN 0-918249-22-8

The Air Force, the Army, and the Navy; Departments of. 1978. *Facility Design and Planning, Engineering Weather Data.* Washington D.C. AFM-29/TM 5-785/NAVFAC P-89.

Wallace, R. (National Park Service). 1996. Personal Communication to Author. 20 September.

APPENDIX A.

KEY TO ENERGY EFFICIENCY RECOMMENDATIONS IN: "GUIDELINES FOR REHABILITATING BUILDINGS AT THE PRESIDIO OF SAN FRANCISCO" (NPS 1995)

with some references to "Guiding Principles of Sustainable Design" (NPS 1993)

1) EMPLOYING APPROPRIATE DESIGN PROFESSIONALS

Seminal Recommendation
p 159
"A thorough understanding of both preservation and sustainable design will inform the design solution."

Supplementary Recommendation(s)
p 138, 161

2) RESPECTING ORIGINAL DESIGN INTENT

Seminal Recommendation
p 172
"Identify and evaluate existing historic features to assess their inherent energy conserving potential prior to retrofitting historic buildings to make them more energy-efficient. Some character-defining features of a historic building or site--such as cupolas, shutters, transoms, skylights, sunrooms, porches, and plantings--may also play a major energy conserving role. If retrofitting is necessary, it needs to be carried out with particular care to ensure that the buildings historic character is preserved in the process of rehabilitation."

Supplementary Recommendation(s)
p 161, 170, 176

3) PROGRAMMING (AVOIDING NEW ADDITIONS)

Seminal Recommendation
p 171
"In addition to both passive and active measures that can be introduced into building design to reduce energy consumption, another important aspect of energy conservation is that older buildings already embody energy conservation value. New construction can only require more energy because of the need for new building materials and associated transportation. All demolition and alteration consumes energy--this energy consumption is further exacerbated when the existing work being demolished or altered is well built of durable, permanent, natural materials. When new

products are necessary, durable locally produced, natural and recycled materials will usually prove more energy efficient than low-quality, imported or manufactured materials."

Supplementary Recommendation(s)
p 122, 123, 125, 159

4) PROGRAMMING (MATCHING USES TO SPACES)

Seminal Recommendation
p 159
"Carefully match the proposed building program to the existing building so the need for additional light, ventilation, or heating is minimized."

Supplementary Recommendation(s)
p 159, 162, 166

5) MAINTENANCE (IN THE DESIGN PROCESS: PLANNING FOR AND ASSUMPTION OF)

Seminal Recommendation
p 159
"Perform routine maintenance, such as cyclical cleaning of filters to assure the optimal efficiency as well as longevity of a system."

Supplementary Recommendation(s)
p 162(2), 174

6) WINDOWS (& SKYLIGHTS INCLUDING: DAYLIGHTING AND OPERABLE WINDOWS FOR NATURAL VENTILATION)

Seminal Recommendation
p 100
"Windows admit light and air to a building. In considering sustainability, both of these functions must be maximized, but in a controlled manner. Admitting natural light to all spaces, while limiting ultraviolet radiation and excessive heat gain through the use of appropriate shading devices, is one important step. Weather stripping and regular maintenance will also increase thermal efficiency. In some cases, the installation of insulating or low-E glazing or glass-applied film may be an appropriate energy saving device. The Presidio's climate rarely requires air conditioning; well-maintained, operable windows will be an important and preferred component in creating an efficient ventilating system for most buildings. Replacement windows and components, when required, should be constructed of environmentally sound materials of the highest quality."

Supplementary Recommendation(s)

operable windows & ventilation: p 94 (figure) 99, 102(2), 103, 105, 159, 163, 164(2), 170, 173, 174 (4), 175, 176
shading: p 74 (figure), p 104 (2), 107, 109, 173(3), 175, 176 (figure), misc. figures
glazing: p 101, 102, 103, 109(2), 176, 207, 209, 210
daylighting: p 87, 89, 99(2), 103, 105, 144, 145(2), 146, 147, 154, 159, 164, 170(2), 172(2), 173(2), 174(2), 176, 177 (figure), 210, misc. figures

7) LIGHTING

Seminal Recommendation
p 177 (see also figures)
"Reduce the large amount of energy expended for lighting by:

- using daylight wherever possible;
- using fluorescent instead of incandescent figures;
- using appropriate lighting for tasks combined with a lower level of ambient lighting;
- implementing controls to limit lighting use, such as occupant activated light[ing]."

Supplementary Recommendation(s)
p 26(2), 158, 159, 164, 204, 214, misc. figures, (NPS Guiding Principles.... 1993, p 14, p 72-73)

8) EQUIPMENT (PLUG LOADS)

Seminal Recommendation
p 177
"Reduce a building's electrical load with a careful selection of energy-efficient equipment, computers, and appliances."

Supplementary Recommendation(s)
p 153

9) LIMITED NEED FOR AIR CONDITIONING

Seminal Recommendation
p 159
"Since most Presidio buildings were originally designed to take advantage of natural light and ventilation, there should be little need for air conditioning if windows are operable and adequate ventilation is provided."

Supplementary Recommendation(s)
p 100, 166, 170, (NPS Guiding Principles.... 1993, p 60-62, p 72)
improving thermal performance/solar control of building: p 3, 74 (figure), 89, 94, 102, 107, 109, 112, 113, 159, 162, 163(2), 167, 170, 171, 172(2), 173(2), 174, 175(2), 176(3), 215, misc. figures, (NPS Guiding Principles.... 1993, p 60-62)

10) CONTROLS (& ZONING)

Seminal Recommendation
p 175
“Provide zoning and operational controls for all systems; regularly assess the system’s performance and level of energy use.”

Supplementary Recommendation(s)
p 159, 177, 216, (NPS Guiding Principles.... 1993, p 14, p 73)

11) EDUCATION FOR OCCUPANTS

Seminal Recommendation
p 171
“Energy conservation goals for the Presidio include:.... to promote energy awareness among both occupants and visitors, through signs, educational programs, incentives, etc.”

Supplementary Recommendation(s)
p 172, (NPS Guiding Principles.... 1993, p 14, p 72)

APPENDIX B.

CHARRETTE COMMITTEE CHAIRS

STEERING COMMITTEE

Co-chairs: Tom Riley and Ann McCormick

Measurement and Monitoring Committee
  Chair: Tai Voong (with Steve Greenberg)
Modeling Committee
  Chair: Jim Waltz (with Dennis Kincy)
Building Envelope and Historical Preservation (Architectural) Committee
  Chair: Dale Sartor
HVAC and Controls Committee
  Chair: Frank Mayhew
Lighting Committee
  Chair: Scott Wentworth
Presentation Committee
  Chair: Rich McClure

The steering, measurement and monitoring, and modeling committees began their work prior to the charrette, preparing information for the use by the other participants. After the event, some of the other charrette participants also contributed to the documentation of the proceedings, the creation of the guidelines and the preparation of this report:

Karl Brown (Design Integration, HVAC and Controls, Presentation)
Doug Lockhart (HVAC and Controls)
Doug Chamberlin (Presentation)
Brain Hines (HVAC and Controls)