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PASSIVE SOLAR COMMERCIAL BUILDINGS: ANALYSIS OF OCCUPANT EFFECTS, INTERACTIONS AND SATISFACTION

Min Kantrowitz & Associates, Inc.

April 1985

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PASSIVE SOLAR COMMERCIAL BUILDINGS:

Analysis of Occupant Effects, Interactions, and Satisfaction

by

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for the

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SOLAR BUILDINGS RESEARCH AND DEVELOPMENT PROGRAM
CONTEXT STATEMENT
November 21, 1985

In keeping with the national energy policy goal of fostering an adequate supply of energy at a reasonable cost, the United States Department of Energy (DOE) supports a variety of programs to promote a balanced and mixed energy resource system. The mission of the DOE Solar Buildings Research and Development Program is to support this goal, by providing for the development of solar technology alternatives for the buildings sector. It is the goal of the program to establish a proven technology base to allow industry to develop solar products and designs for buildings which are economically competitive and can contribute significantly to building energy supplies nationally. Toward this end, the program sponsors research activities related to increasing the efficiency, reducing the cost, and improving the long-term durability of passive and active solar systems for building water and space heating, cooling, and daylighting applications. These activities are conducted in four major areas: Advanced Passive Solar Materials Research, Collector Technology Research, Cooling Systems Research, and Systems Analysis and Applications Research.

Advanced Passive Solar Materials Research. This activity area includes work on new aperture materials for controlling solar heat gains, and for enhancing the use of daylight for building interior lighting purposes. It also encompasses work on low-cost thermal storage materials that have high thermal storage capacity and can be integrated with conventional building elements, and work on materials and methods to transport thermal energy efficiently between any building exterior surface and the building interior by nonmechanical means.

Collector Technology Research. This activity area encompasses work on advanced low-to-medium temperature (up to 180 °F useful operating temperature) flat plate collectors for water and space heating applications, and medium-to-high temperature (up to 400 °F useful operating temperature) evacuated tube/concentrating collectors for space heating and cooling applications. The focus is on design innovations using new materials and fabrication techniques.

Cooling Systems Research. This activity area involves research on high performance dehumidifiers and chillers that can operate efficiently with the variable thermal outputs and delivery temperatures associated with solar collectors. It also includes work on advanced passive cooling techniques.

Systems Analysis and Applications Research. This activity area encompasses experimental testing, analysis, and evaluation of solar heating, cooling, and daylighting systems for residential and nonresidential buildings. This involves system integration studies, the development of design and analysis tools, and the establishment of overall cost, performance, and durability targets for various technology or system options.

This report is an account of research conducted in systems analysis and applications concerning an analysis of the interactions between passive buildings and occupants based on data collected through the Nonresidential Experimental Buildings Program.

EXECUTIVE SUMMARY

Approach

In 1979 the U.S. Department of Energy launched the Nonresidential Experimental Buildings Program to investigate the potential of passive solar technologies to meet the heating, cooling, and lighting requirements of nonresidential buildings. The program provided technical and financial support for a number of innovative nonresidential passive solar buildings around the country. The program's intent was to systematically investigate the potential for using passive solar techniques to reduce auxiliary energy use in commercial buildings.

Two major questions underlie this Evaluation - Did the buildings save auxiliary energy and did they function as well as non-solar buildings? Occupancy evaluation focused on occupant impacts on building energy use and user satisfaction with the building environment (particularly as it related to the building energy system design). Both of these questions must be answered affirmatively for the buildings to be considered successful.

Each project (building) in the Program was required to complete one year of monitoring and data collection designed to evaluate the performance of the building according to Standard Operating Procedures developed by the Department of Energy and its consultants. Each project team received a set of data collection and reporting forms, accompanied by explanatory manuals which describe the data collection procedures in detail. Basically, each project team reported its projected energy use and the design and operational assumptions which underlie those predictions. Then, monthly reports of energy use, building operations and a variety of occupancy factors are submitted. Occupancy effects are assessed in a variety of ways. Full-time and part-time building users were asked to complete a questionnaire each month. Building operators and managers responded to a number of operations and occupancy-related questions as part of their monthly reporting. Site visits and observations occurred at most buildings. Interviews were conducted with architects, building program personnel, building managers and selected staff on an as-needed basis.

Results

Passive solar commercial buildings can provide their users with environments which are thermally comfortable, with acceptable lighting and air quality conditions, while saving significant amounts of auxiliary energy. In other words, the significant reduction in energy use over base case comparisons for these buildings is <u>not</u> accomplished at the expense of occupant comfort.

These results counter past assumptions that nonresidential buildings were unlikely candidates for passive solar technology by virtue of their high internal heat gains, large volume, and narrow bands of allowable environmental conditions. The buildings in the Passive Solar Nonresidential Buildings program saved significant amounts of energy at little, if any, extra cost. Occupant satisfaction was above average. Moreover, user operation and use of the buildings had a significant impact on auxiliary energy consumption.

A number of program findings indicate that passive solar design for commercial buildings still needs more work to optimize both energy savings and user satisfaction. The outstanding issues include:

- Patterns of cool mornings and warm afternoons, particularly in high mass buildings
- Acoustical problems
- Difficulty with proper operation of multipurpose building elements.
- User involvement with planned building operations - issue of distribution of environmental controls between users and automated systems
- High impact of changed use patterns on energy consumption

These issues indicate the need for further research in user interactions with their buildings and for more systematic consideration of occupant effects in programming and designing energy efficient buildings.

I. INTRODUCTION

Over the last decade, passive solar design concepts have been successfully demonstrated in residential buildings throughout the country. In contrast, professional designers have been much slower to adapt passive design concepts to commercial buildings -- despite large potential energy savings in that sector. A number of factors are responsible for the slow acceptance of non-residential passive solar including:

- Lack of reliable data on real passive solar commercial buildings
- Designers' relative inexperience with large-scale passive solar design
- Greater financial risk associated with incorporating new approaches in large building projects

In 1979 the DOE launched the Non-Residential Experimental Buildings Program to investigate the potential of passive solar technologies to meet the heating, cooling, and lighting requirements of non-residential buildings. The program provided technical and financial support for a number of innovative non residential passive solar buildings around the country. The program's intent was to systematically investigate the potential for using passive solar techniques to reduce auxiliary energy use in commercial buildings.

Specifically, the objectives of this DOE program were:

- To stimulate the reduction of energy consumption of new and existing commercial buildings through the effective use of energy conservation and passive solar design techniques.
- To support the design and implementation of exemplary and prototypical passive solar commercial buildings.
- To identify the cost and performance of passive systems in commercial buildings.
- To provide information and data for the purpose of identifying user requirements for needed passive design tools and for validating existing passive tools.
- To demonstrate the practical and architecturally pleasing opportunities of passive system use in commercial buildings.

There were three phases in the program: design, construction, and performance evaluation.

In the design phase, project designers were reviewed by a panel of technical experts in a series of meetings. The objective of the reviews

was to ensure that designs effectively integrated strategies for passive cooling, lighting and heating with each other, with the buildings, and with the auxiliary mechanical and lighting systems. During the design of these buildings, under Phase I, a team of technical experts helped each project architect maximize energy performance, enhance occupant comfort, and minimize construction cost. Each project team started by establishing a "base-case" building, a non-solar building the owner would have probably ordinarily built. Team members then calculated heating, cooling, lighting and other energy requirements, taking into consideration heat generated within the building by people and lights, occupant behavior, climate and construction practice. These buildings were to reflect "state-of-the-art" design practice for energy conservation.

Designers then developed passive design schemes and estimated their costs and energy performance. Energy estimate techniques ranged from calculations of Los Alamos Scientific Laboratory solar load ratio or solar savings fraction, to computer simulation using mainframe programs developed by federal and private sector groups. The design had to be aesthetically pleasing, integrate mechanical, lighting and other support systems, demonstrate "technical validity" and address the building's major energy cost requirements. The costs of the passive features had to be reasonable as measured by life cycle cost analysis. The resulting array of design showed bias toward south-facing roof apertures that provided both heat a light, Trombe walls, and circulation spaces that collected heat for distribution around the rest of the building. Glare and overheating were to be prevented by diffusing baffles, overhangs, and operable shades. Night flushing, and natural ventilation supplied the bulk of cooling. Both automatic and manual controls were represented.

The buildings in the program encompass a broad spectrum of building types, climate locations and design strategies as shown in Figure I-1. The projects range from a 700 square foot classroom module in Alaska to a 66,700 square foot airport in Colorado and comprise a variety of building types, including office buildings, community centers, an automobile maintenance shop, a bank and several educational use buildings. Designs focus on passive heating, cooling and daylighting strategies for reducing energy consumption.

Following building construction, each of the projects in the Program underwent a comprehensive performance evaluation, based on a standardized data collection system. The Performance Evaluation Phase of the program was designed to examine how well the energy efficient buildings actually work. Evaluations of energy use, construction and operations costs and occupant factors were carried out in addition to special studies examining some of the integration issues. After five years, the buildings have completed the design and construction phases and performance monitoring phase, compiling results relative to energy consumption, economic performance, and occupancy effects.

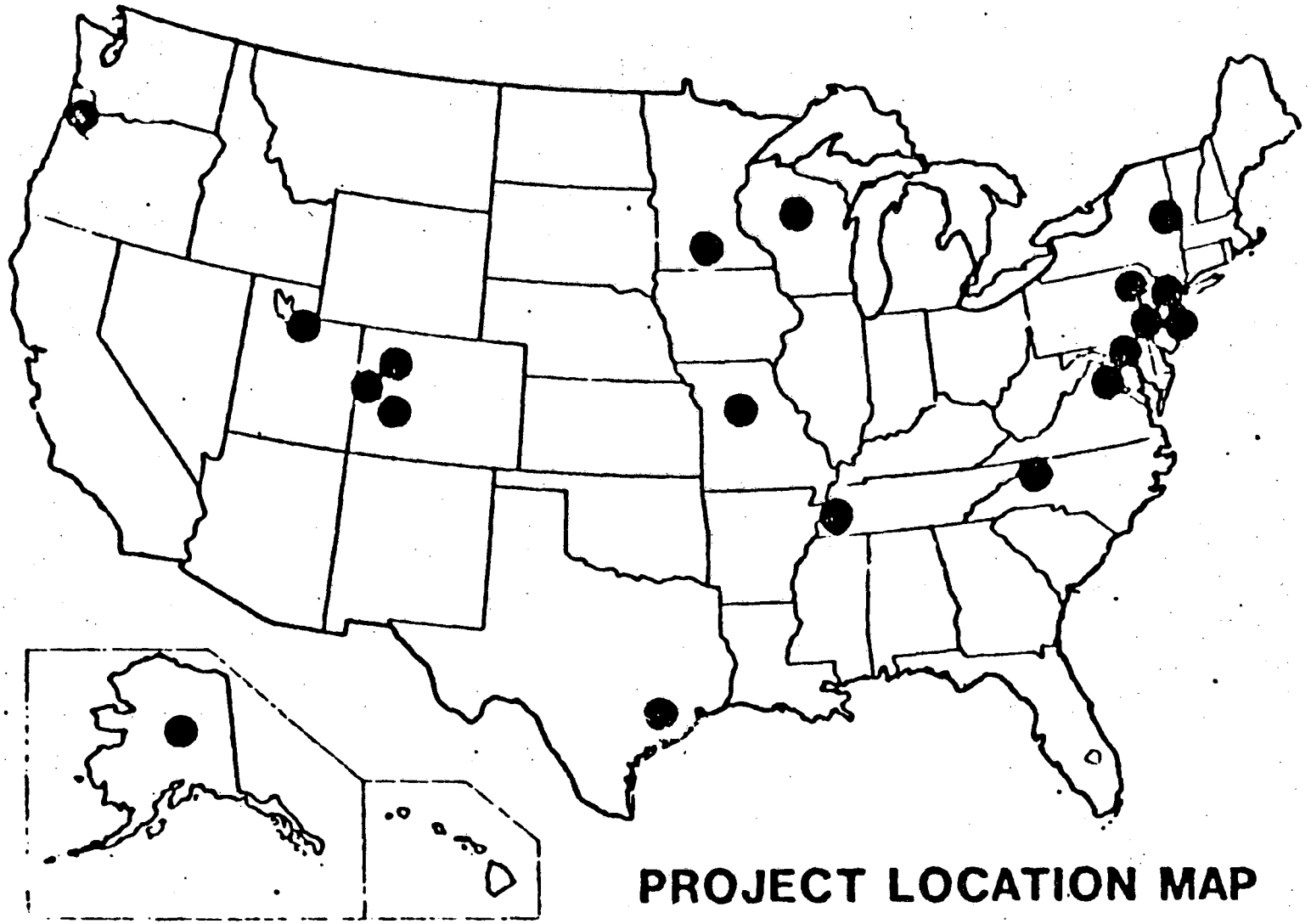

Figure I - 1

These data relate to the three hypotheses that underlie the Program. These hypotheses are:

. Passive design affects building energy performance.
. Building performance influences occupant reactions.
. Occupant behavior affects building energy performance.

The Occupancy Evaluation component of the Performance Evaluation addresses the second and third hypotheses.

Information was collected relating to these hypotheses from each building in the program according to a standardized system of comparing baseline predictive information with actual performance data submitted monthly. The standardized questionnaires and other data collection instruments were designed to collect a range of information for EACH building for EACH month of a 12 month monitoring period. After data collection was complete, it was possible to characterize the relationship between a building and its occupants over a year AND to compare passive solar approaches, occupant responses and other parameters across buildings.

The basic framework for the evaluations asks two questions: "do the buildings save auxiliary energy?" and "do the buildings work as well as non solar equivalents?" The occupant performance evaluation work focuses on user factors which influence:

- auxiliary energy use
- the functioning of the solar components of the buildings
- occupant satisfaction with the environment, particularly to passive solar features.

Data from 17 buildings form the basis of the findings presented here, since these buildings have completed all or a significant portion of their data collection activities by the appropriate data analysis cut off point. These buildings are:

- Gunnison County Airport; a 9,700 s.f. airport in Gunnison, Colorado
- RPI Visitor Center; a 5,200 s.f. office and police headquarters building in Troy, New York
- Community United Methodist Church, a 5,500 s.f. educational and community building in Columbia, Missouri
- Comal County; a retrofit of a 4,800 s.f. school building in New Braunfels, Texas, now used as a training facility for developmentally disabled adults

- Johnson Controls Branch Office; a 15,000 s.f. office building in Salt Lake City, Utah

- Mt. Airy Public Library, a 13,500 s.f. community library in North Carolina

- Blake Avenue College Center of Colorado Mountain College, a 32,000 s.f. community college building in Glenwood Springs, Colorado

- Princeton Professional Park, a 64,000 s.f. speculative office building complex in Princeton, New Jersey

- Princeton School of Architecture Building, retrofit of a 13,700 s.f. education building in Princeton, New Jersey

- St. Mary's School Gymnasium, addition of a 9,000 s.f. gymnasium to an existing building in Alexandria, Virginia

- Kieffer Store, a 3,200 s.f. retail store in Wausau, Wisconsin

- Security State Bank, and 11,000 s.f. bank in Wells, Minnesota

- Essex Dorsey Senior Center, a 13,000 s.f multipurpose senior center in Baltimore, Maryland

- Shelly Ridge Girl Scout Center, a 5,700 s.f. community education facility near Philadelphia, Pennsylvania

- Walker Field Airport, a 66,700 s.f. airport terminal in Grand Junction, Colorado

- Philadelphia Automobile Maintenance Facility, retrofit of an old 57,000 s.f. auto repair and maintenance building in downtown Philadelphia, Pennsylvania

- Two Rivers School, a 15,750 s.f. elementary school outside Fairbanks, Alaska

II. METHODOLOGY

Two major questions underlie this Evaluation - Did the buildings save auxiliary energy and did they function as well as non-solar buildings?. Occupancy evaluation focused on occupant impacts on building energy use and user satisfaction with the building environment (particularly as it related to the building energy system design). Both of these questions must be answered affirmatively for the buildings to be considered successful.

Each project (building) in the Program was required to complete one year of monitoring and data collection designed to evaluate the performance of the building according to Standard Operating Procedures developed by the Department of Energy and its consultants. Each project team received a set of data collection and reporting forms, accompanied by explanatory manuals which describe the data collection procedures in detail. Basically, each project team reported its projected energy use and the design and operational assumptions which underlie those predictions. Then, monthly reports of energy use, building operations and a variety of occupancy factors are submitted.

For each building, monthly measurements of building energy use, collected either by manual (submetered) or automatic data collection equipment, were compared to predicted energy use, and discrepancies between the two analyzed. Possible reasons for differences included poor predictions, design errors, construction mistakes, unusual weather patterns, and a variety of occupancy factors. Comparisons of monthly building performance with that predicted, along with information on occupant satisfaction and comfort was the basis for performance evaluation of the building.

Occupancy issues were assessed in a number of ways. A chart illustrating the interrelationships between questions is included in Appendix I. Full-time and part-time building users were asked to complete a questionnaire each month. Building operators and managers responded to a number of operations and occupancy related questions as part of their monthly reporting. Site visits and observations occurred at most buildings. Interviews were conducted with architects, building program personnel, building managers and selected staff on an as needed basis.

The standardized questionnaires and other data collection instruments were designed to collect a range of information for EACH building for EACH month of a 12 month monitoring period. After data collection was complete, it was possible to characterize the relationship between a building and its occupants on a month by month basis over the year monitoring period AND to compare passive solar approaches, occupant responses and other parameters across buildings.

The Full-Time and Part-Time questionnaires, and other data collection forms may be found in Appendix I.

The data compilation for analysis of occupancy evaluation of projects in the Passive Solar Commercial Buildings Program followed a format for tabulating monthly user responses. This format (included in Appendix I) was used to translate user responses into manageable frameworks which address specific occupancy related concerns. After monitoring was complete for each building, data were consolidated for each month of monitoring and across the entire monitoring period. While the research methods used preclude the use of parametric statistics, nonparametric methods were used in data analysis.

PERFORMANCE EVALUATION CONCEPTS

The Performance Evaluation System can be viewed conceptually according to Figure II - 1. It is structured along two dimensions:

- Do the buildings save auxiliary energy?
- Do they function as well as non-solar buildings?

Imbedded within these questions are a variety of occupant oriented hypotheses, including:

- Users will manipulate the building to achieve comfort, either by the means intended by the designer, or by any other means they can devise.

- Changes in occupancy patterns (number, timing, activity, and location) will have profound influence on energy use and operational characteristics of the buildings.

- "Educated" users and building operations staff are more likely to achieve expected levels of energy performance in a building. Passive solar buildings are especially sensitive to interactive effects which can be influenced by a wide variety of improper or unexpected patterns of building operations.

- Clarity in roles and responsibilities for building operation is crucial in passive solar commercial buildings, since these are not usual "automatic" commercial buildings.

- User comfort (thermal, acoustic, air quality and lighting) can be achieved in passive solar commercial buildings, but some problems in these areas are to be expected.

The methodology developed for the Passive Solar Commercial Buildings Program was designed to be as flexible as possible, to allow the wide variety of building occupancy conditions to be recorded on the same sets of reporting forms. As a result, user reactions to some of the unique features of each individual building could not be systematically queried. More qualitative research methods such as informal observations and telephone interviews were relied upon to examine these features.

PERFORMANCE EVALUATION

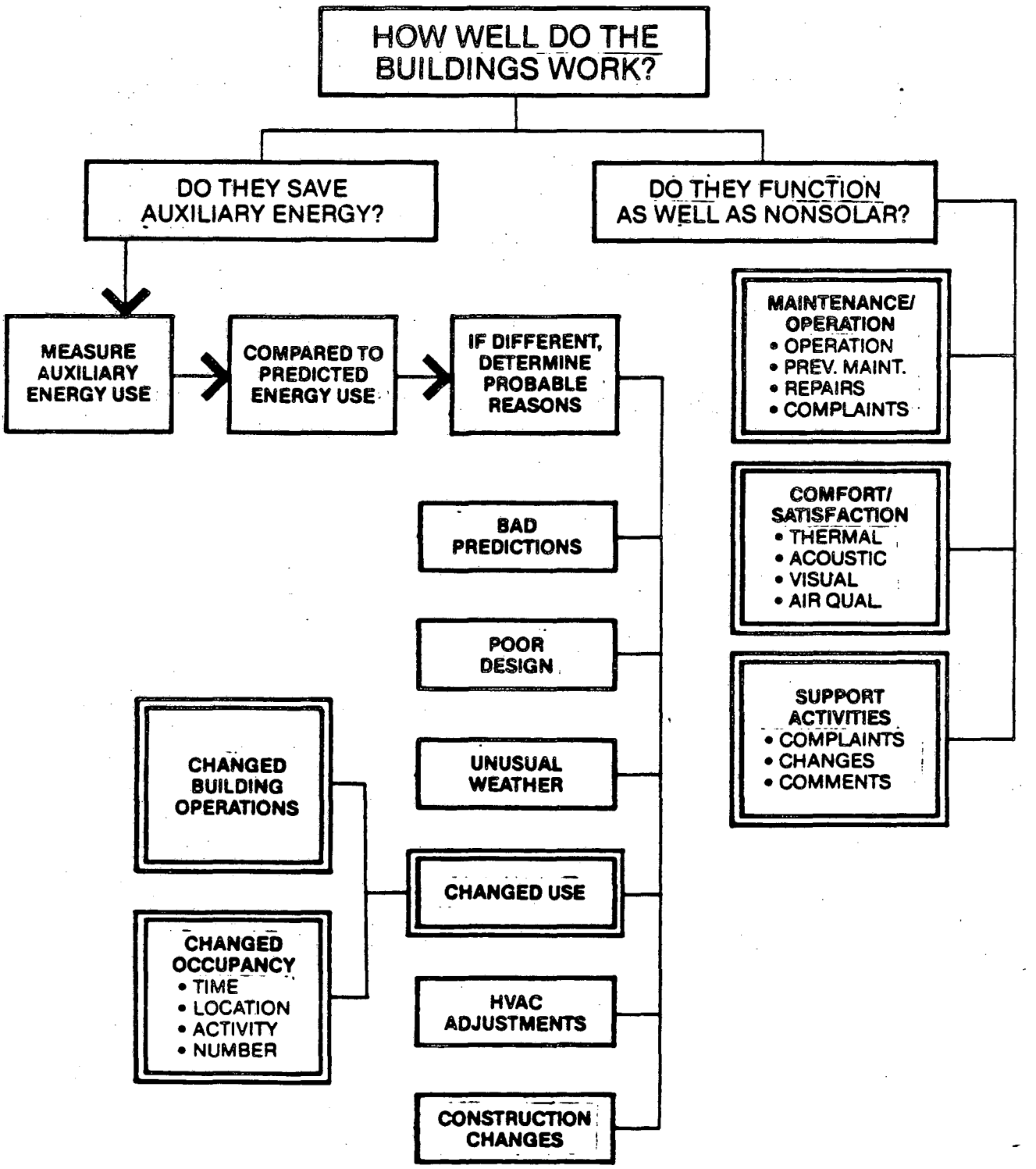

Figure II - 1

DATA QUALITY

Several comments about data quality are important to make in this overview. First, as in all volunteer responses to written questionnaires, the data are subject to the usual biases of self-reporting. These include both tendencies to over report problems and tendencies to over report satisfaction, often depending on the social, political or administrative role of the respondent within the organization housed in the building. Second, response rates varied widely from one building to another, largely due to the motivation level of the individual responsible for data gathering at the site. In those situations where there was multiple control or unclear division of responsibility for data collection, the consistency of reporting was relatively poor. In some buildings where communication between occupant organizations, owners and performance monitoring teams was infrequent or indistinct, data quality suffered. Although contractual obligations specified that both energy use data and occupancy data were required to be collected each month, teams from some buildings only partially complied and recorded only energy use data.

The number, activity, location and timing of occupancy as predicted during design was the basis for energy use predictions. However, these frequently changed significantly before occupancy of the building. As a result, some discrepancies between predicted energy use and actual energy use could be anticipated just on the basis of changed occupancy patterns.

Since each building project team used different methods for predicting building energy use, as well as different monitoring methods for determining actual auxiliary energy use, it is unclear to what extent energy savings results are directly comparable across buildings.

Despite these caveats, however, the results of this research constitute the largest data base available on passive solar nonresidential buildings and are the first attempt to directly relate actual energy performance of a number of innovative passive solar buildings with user satisfaction and interactions with building function. Patterns of building function and user response can be determined and can provide a rich source of information for future design and research on passive solar nonresidential buildings.

Table II-1 indicates for which months buildings transmitted Full Time user questionnaires to the Performance Evaluation consultant. Table II-2 indicates the same information for Part Time User questionnaires.

FULL TIME USER DATA AVAILABILITY

TABLE II - 1

	ALASKA TWO RIVERS SCHOOL	COMAL COUNTY MH/MR CENTER	COMMUNITY UNITED METHODIST CHURCH	ESSEX DORSEY SENIOR CENTER	GUNNISON AIRPORT	JOHNSON CONTROLS	KIEFFER STORE	PHILADELPHIA MUNICIPAL AUTO SHOP	PRINCETON PROFESSIONAL PARK	PRINCETON SCHOOL OF ARCHITECTURE	RPI VISITOR CENTER	SECURITY STATE BANK OF WELLS	SHELLY RIDGE	ST. MARY'S ADDITION	WALKER FIELD	TOTAL RSPS
1981																
October							●									1
November							●									1
December							●									1
1982																
January							●									1
February							●									1
March			●				●									2
April			●				●									3
May			●		●		●				●					18
June			●		●	●	●									28
July			●		●		●				●					19
August			●		●		●				●					17
September						●					●					25
October		●				●	●				●					17
November		●				●	●									11
December		●				●	●				●					37
1983																
January		●					●				●					11
February		●	●				●				●					18
March		●	●			●	●				●					32
April		●					●				●					17
May		●														9
June		●														8
July		●														4
August								●								27
September																1
October	●		●					●								47
November											●					9
December										●						21

TABLE II - 1 - FULL TIME USER DATA AVAILABILITY - (continued)

	ALASKA TWO RIVERS SCHOOL	COMAL COUNTY MH/MR CENTER	COMMUNITY UNITED METHODIST CHURCH	ESSEX DORSEY SENIOR CENTER	GUNNISON AIRPORT	JOHNSON CONTROLS	KIEFFER STORE	PHILADELPHIA MUNICIPAL AUTO SHOP	PRINCETON PROFESSIONAL PARK	PRINCETON SCHOOL OF ARCHITECTURE	RPI VISITOR CENTER	SECURITY STATE BANK OF WELLS	SHELLY RIDGE	ST. MARY'S ADDITION	WALKER FIELD	TOTAL RSPS
1984																
January				●						●	●	●		●		30
February				●						●	●	●		●		35
March				●					●	●		●	●	●		32
April				●					●	●		●	●	●		34
May									●	●	●	●				35
June									●						●	20
July												●			●	2
August															●	9
September												●	●			7
October												●				1
November												●				4
December												●				5
1985																
January				●												16

PART TIME USER DATA AVAILABILITY

TABLE II - 2

	COMMUNITY UNITED METHODIST CHURCH	JOHNSON CONTROLS	KIEFFER STORE	RPI VISITOR CENTER	SECURITY STATE BANK OF WELLS	SHELLY RIDGE	ST. MARY'S ADDITION	WALKER FIELD	TOTAL RSPS
1981									
October			●						1
November			●						1
December			●						1
1982									
January			●						1
February			●						1
March			●						1
April	●		●						22
May	●		●	●					28
June	●	●							7
July			●						1
August			●	●					3
September	●	●	●						5
October	●		●	●					9
November			●						1
December		●	●						3
1983									
January	●		●	●					9
February	●		●						17
March	●	●	●						17
April	●		●						5
May	●						●		8
June	●						●		3
July									--
August									--
September							●		1
October							●		4
November							●		4
December							●		4

TABLE II - 2 - PART TIME USER DATA AVAILABILITY - (continued)

	COMMUNITY UNITED METHODIST CHURCH	JOHNSON CONTROLS	KIEFFER STORE	RPI VISITOR CENTER	SECURITY STATE BANK OF WELLS	SHELLY RIDGE	ST. MARY'S ADDITION	WALKER FIELD	TOTAL RSPS
1984									
January					●		●		5
February					●		●		10
March					●	●	●		18
April					●	●	●		11
May								●	9
June						●		●	7
July						●		●	3
August								●	3
September					●	●			5
October					●				2
November					●				3
December					●				1
1985									
January									--

III. CONCLUSIONS

SUMMARY

Passive solar commercial buildings can provide their users with environments which are thermally comfortable, with acceptable lighting and air quality conditions, while saving significant amounts of auxiliary energy. In other words, the 45% reduction in energy use over base case (see Performance Evaluation Overview Report, 1985) is not accomplished at the expense of occupant comfort.

These results counter past assumptions that non residential buildings were unlikely candidates for passive solar technology by virtue of their high internal heat gains, large volume, and narrow bands of allowable environmental conditions. The buildings in the Passive Solar Nonresidential Buildings program saved significant amounts of energy at little, if any, extra cost. Occupant satisfaction was above average. Moreover, user operation and use of the buildings had a significant impact on auxiliary energy consumption.

A number of program findings indicate that passive solar design for commercial buildings still needs more work to optimize both energy savings and user satisfaction. The outstanding issues include:

- Patterns of cool mornings and warm afternoons, particularly in high mass buildings.
- Acoustical problems
- Difficulty with proper operation of multipurpose building elements.
- User involvement with planned building operations - issue of distribution of environmental controls between users and automated systems
- High impact of changed use patterns on energy consumption

These issues indicate the need for further research in user interactions with their buildings and for more systematic consideration of occupant effects in programming and designing energy efficient buildings.

The results which follow are based on a number of documents (see Appendix II, References), including individual reports prepared by MKA on 15 of the buildings in the program. Summary data on responses to Full Time User Questionnaires is found at the end of this section, on Table III-1. Part Time User Questionnaires are summarized in Table III-2. User satisfaction related responses by Full Time Users may be found on Table III-3; a similar summary for Part Time Users is on Table III-4.

A. SATISFACTION

1. Overall Satisfaction With the Buildings was High.

Figure III-1 illustrates the month by month overall satisfaction reported by building occupants on a 6 point scale.

Although satisfaction did fluctuate some for each individual building, the pattern indicates a high degree of satisfaction with all buildings in all seasons of the year. A large majority of respondents liked the appearance of these buildings more than other buildings serving the same function.

2. The Popularity of Some Buildings Led to Longer Hours of Operations and Significantly Increased Occupancy Levels.

Nine of seventeen buildings were used many more hours each week than designers had predicted, while twelve of the seventeen were used by many more people than expected. The only building which was occupied less than predicted was Johnson Controls, which hired fewer people than predicted to occupy the space.

3. Most Users Liked the Appearance of the Buildings and Felt that the Solar Design had a Positive Effect.

The relationship between positive attitude toward building appearance and whether this attitude was affected by the fact that the building was solar was tested statistically. Solar had a significant influence on how well people liked building appearance (CHI SQUARE = 133.96, $p<.001$).

4. Perceived Thermal Comfort was High, averaging 74%

Thermal comfort was generally high throughout the year. Figure III-2 illustrates the pattern of comfort levels; these percentages of "thermally comfortable people" includes those people who said they were occasionally too warm or too cool, but excludes those who reported frequent thermal discomfort. Thermal comfort was reported highest during Spring and Fall seasons, with most complaints during the winter season.

Examination of complaints of frequent thermal discomfort reveals consistent patterns of "too cool mornings" and "too warm afternoons" in several buildings. Perception of cool mornings seems to be related to several factors:

- Setback strategies that were too deep and/or long. Altering setbacks to shallow, stepped or earlier start up approaches solved a number of "cool morning" problems.

- High mass buildings. These buildings took longer to achieve perceived comfort levels than had been anticipated. (See section on Thermal Mass for further discussion of this issue).

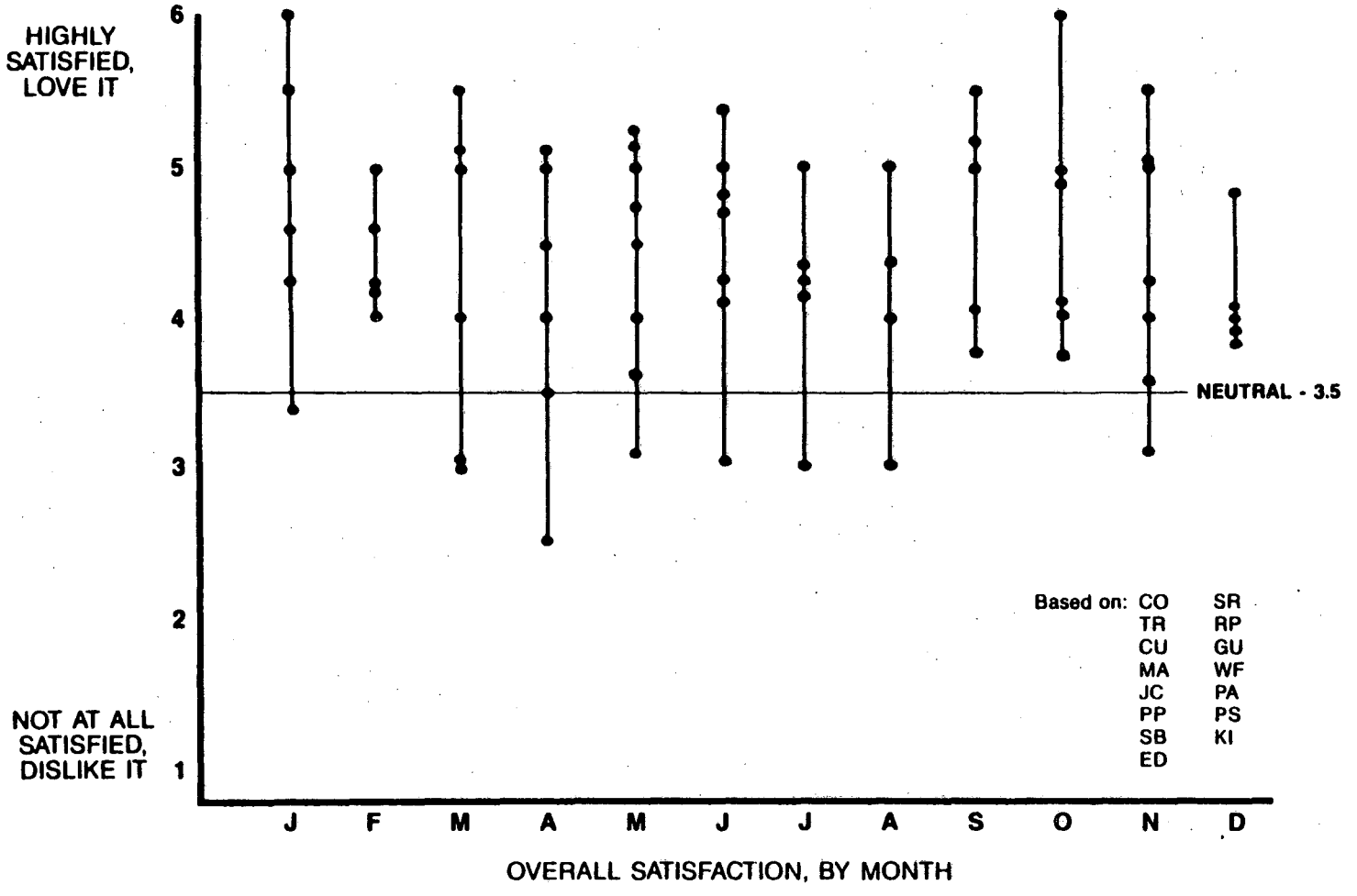
HIGHLY SATISFIED, LOVE IT
NOT AT ALL SATISFIED, DISLIKE IT
6
5
4
3
2
1
NEUTRAL - 3.5
Based on: CO TR CU MA JC PP SB ED
SR RP GU WF PA PS KI
J F M A M J J A S O N D
OVERALL SATISFACTION, BY MONTH

Figure III - 1

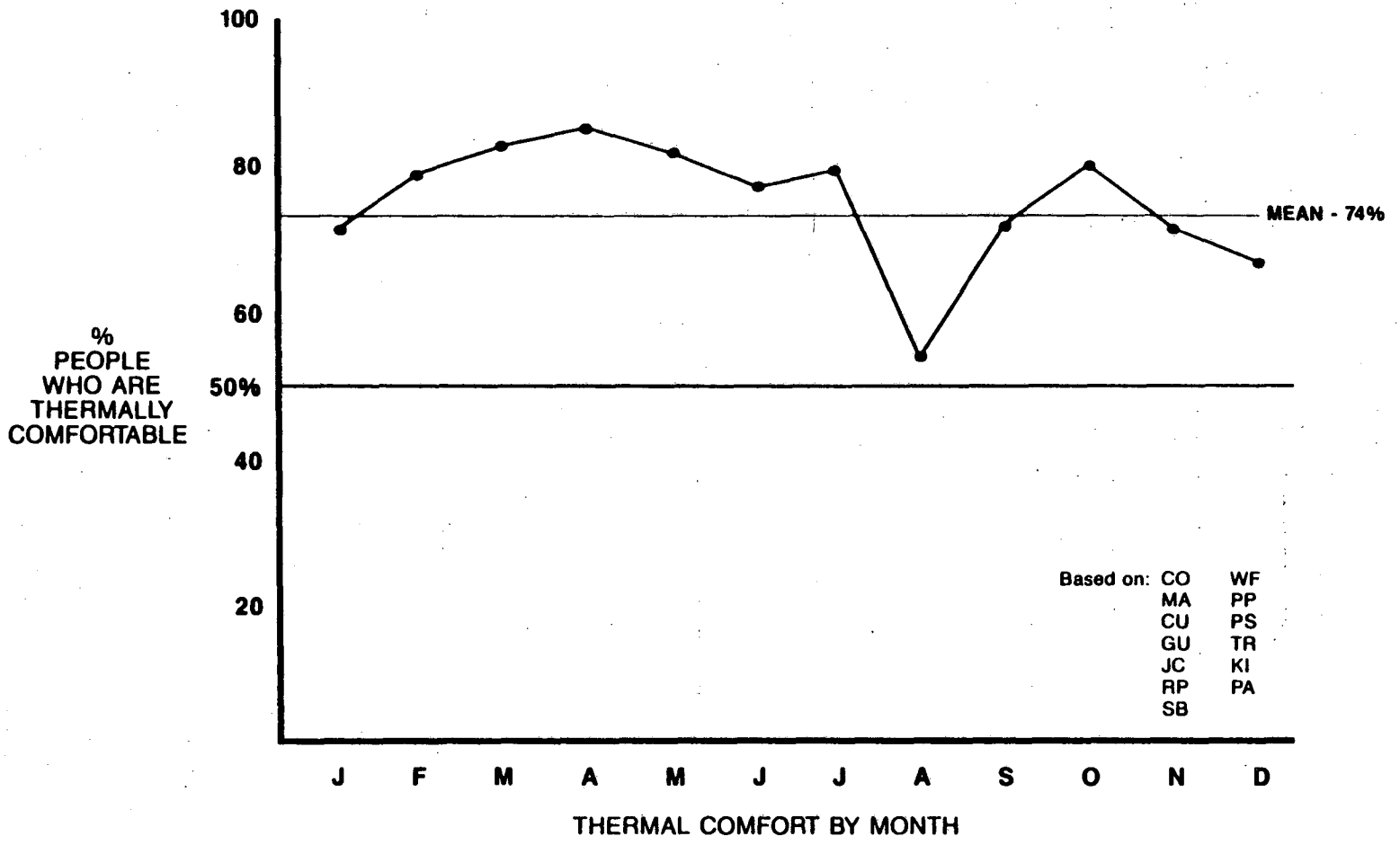
100
80
60
50%
40
20
% PEOPLE WHO ARE THERMALLY COMFORTABLE
MEAN - 74%
Based on: CO MA CU GU JC RP SB
WF PP PS TR KI PA
J F M A M J J A S O N D
THERMAL COMFORT BY MONTH

Figure III - 2

- Changed timing of building use. In several buildings, users were occupying the building earlier in the day than predicted, thus making planned timing of the heat release inappropriate.

Perceived warm afternoons may be related to:

- Increased building use. In some buildings the number of occupants was more than double that predicted.

- Ventilation problems. Shading to decrease solar gain, to reduce glare or darken a room sometimes interfered with ventilation. Fans were sometimes noisy and distracting. In some of the buildings, the cooling strategy included passive convective night ventilation through operable windows and clerestory openings. User concerns about security prevented the use of this strategy in two buildings. Ventilation strategies for cooling had numerous operational problems, interfering with their effectiveness in providing comfort. These are discussed further in the section on Natural Ventilation.

5. Satisfaction with Lighting was Consistently High.

Daylighting was used in 100 percent of the designs and was usually very well received. Users spontaneously mentioned their delight in the daylighting in buildings with a wide variety of daylighting solutions.

Lighting controls varied from automated to manual. Special studies in two of the buildings by Lawrence Berkeley Laboratories indicated that in some cases, users could control the artificial lighting in a more energy efficient manner than artificial lighting controls would have done under the same occupancy conditions (Andersson et al, 1984). In most cases, lighting energy use was lower than predicted.

- Daylighting alone sometimes provided 100% of the illumination needs.

- Artificial lighting and daylighting were well integrated in the buildings, providing acceptable lighting conditions almost all of the time. There were fewer than 5% of respondents who complained of too dim or too bright conditions, regardless of time of year, time of day or building location.

- Glare problems reported in several buildings were usually associated with perimeter light sources rather than overhead light sources.

6. There were Few Perceived Air Quality Problems.

Air quality was generally satisfactory in all buildings, with the only exceptions being in areas which had not initially been designed for human

occupancy. Initial reports of drafty conditions at a few buildings were largely attributed to construction problems which could be remedied.

7. Some Complaints about Acoustics Occurred in the Majority of Buildings Studied.

Some complaints about acoustics occurred in the majority of buildings studied. A number of occupants complained about sound levels and some added acoustically absorptive materials, public address systems and even a "white noise machine."

Four types of perceived acoustical problems were examined: being disturbed by overhearing things, having difficulty on the telephone or with conversations and having difficulty concentrating. Concentration and conversation problems were most frequent.

Acoustic problems were related to:

- Wall and floor surfaces, primarily designed to provide thermal storage mass, were constructed of non absorptive materials and thus bounce sound around the buildings.

- Open plans designed to enhance convective currents prevent sound isolation.

- Increased number of occupants using the buildings.

In response to these findings, parametric tests have been performed at Lawrence Berkeley Laboratory to investigate the effects of responding to these perceived acoustical problems in future designs by increasing acoustical treatment of surfaces which play a role in passive thermal distribution (Andersson et al, 1985). That research found that effective acoustic treatments can be designed which have only marginal effects on building energy requirements.

B. CHANGED BUILDING OCCUPANCY AND USE

Evaluation findings showed that many differences in occupancy patterns and in building operations occurred and that these changes probably strongly influenced actual building energy use, although the exact impact of these changes cannot be determined. In almost all buildings in the program, actual occupancy patterns differed significantly from those predicted.

As indicated on Figure III-3, actual occupancy differed from that predicted in six ways:

1. Timing of Occupancy.

Because the buildings were very popular, people used them many more hours per day than had been predicted. Occupancy began earlier in the day, lasted

BUILDING	CODE	TIMING OF OCCUPANCY	NUMBER OF PEOPLE	DIFFERENT LOCATION	DIFFERENT ACTIVITY	USE OF SPACES DESIGNATED TO BE UNOCCUPIED	CHANGED OPERATIONS
Johnson	JC		−				●
Alaska School	TR	+	+				●
Essey Dorsey	ED	+	+	●	●		●
Mt. Airy	MA	+	+				
Phila Auto	PA			●	●		●
CMC	CM	+	+	●	●	●	
Comal	CO	+	+				●
CUMC	CU	+	+				
Shelly Ridge	SR	+	+				
Gunnison	GU		+		●	●	●
Kiefer	KI						
SAUP	PS				●		●
PPP	PP	+	+	●	●		●
RPI	RP		+	●	●	●	●
Wells	SB		+	●	●	●	●
Walker Field	WF				●		
St. Mary	SM	+	+				

Figure III - 3

longer into evening hours and included significant amounts of weekend use. This resulted in energy demands that had not been anticipated in design.

2. Location of Occupancy.

Spaces which had been designed to be unoccupied were frequently pressed into use, influencing energy use and comfort in those areas. These areas, such as storage areas and mezzanines, were not originally designed to provide comfortable conditions for occupants. In each case, users in those areas experienced some discomfort, and more energy was used trying to achieve comfort than designers had predicted.

3. Number of Occupants.

In all cases but one, buildings in this program were used by many more people than the designers had anticipated. In one case, almost twice as many users as had been anticipated were occupying the space. This popularity put unanticipated demands on the building energy systems.

4. Activity.

Although this type of change in occupancy occurred less frequently than other types, spaces which had been designed to provide thermal comfort conditions appropriate for one set of activities became uncomfortable when other types of activities occurred in the space. For example, in one building, an area designed for quiet activities was used for exercise classes, resulting in uncomfortable conditions.

5. Use of Space Designated to be Unoccupied.

Due to to increased popularity of the buildings, all area under the roof was used by building occupants, including areas that had not been designed to be occuped. For example, when a sunspace designed as a buffer zone was temporarily filled with blackboards and used as a classroom, the users were uncomfortably warm. In addition, the adjoining offices which depended on borrowed light from the sunspace found that the blackboards blocked their light source. In these cases, auxiliary energy was used to re-establish comfort conditions.

6. Changed operations.

This will discussed in greater detail in the next section.

C. CHANGED BUILDING OPERATIONS

Building energy use predictions were based on certain fairly specific operational assumptions. Each design team specified an operational protocol which was used as the basis for their energy use predictions. In addition to predictions of number of occupants, these assumptions ranged

from straightforward instructions specifying when to switch a system from summer mode to winter mode, to fairly complex and subtle directions indicating what sequence of actions should be taken if the building became too warm during Spring and Fall seasons.

For some buildings, these operational protocols were explicitly transferred to the building users through written instructions, in others through a verbal briefing to the building users, in still others the actual building operation was directly in the hands of an on-site building manager.

Most building users were interested in how the buildings were supposed to work and wanted to be able to control their environments. When properly instructed, users could operate manual controls properly, but some strategies were more effective than others.

Efforts to teach occupants to understand building operations ranged from short discussions to complex written documents. The most effective communication recognized the needs, education, motivation, interests and sophistication of the users. Complete detailed instructions which are inappropriate to the audience were neither understood nor applied.

Controls were used best when they were:

- Familiar in operational concept - e.g., blinds
- Logically connected to users so that the impact of user operation on comfort conditions could be felt directly
- Located close to users to minimize effort
- Simple to understand and operate

User controls are less effective when they are:

- Counter intuitive
- Multipurpose-users confuse purposes
- Part of a heirarchy of actions, since people forget the proper order.

If people could not get comfortable doing the building operations over which they had control by doing something that seemed simple and familiar, they tried all sorts of other strategies including breaking into locked panel boxes and adding a variety of energy consuming equipment.

Building operations differed from those initially planned for a number of reasons.

1C. <u>Changed Use Made Planned Operations Inappropriate.</u>

In some cases the use patterns had so significantly altered from those predicted that operations had to change as well in order to provide comfortable conditions.

2. Instructions were Inappropriate

To be effective, operational instructions must respond to the needs, education, motivation, interests or sophistication of the building users. Sometimes only a few users received instructions, sometimes the user population changed and the new occupants were never instructed, while sometimes the language, format, and distribution of written information was too sophisticated for the building users.

3. Instructions were Not Transferred

The question of who has responsibility for effective transfer of operational instructions is sometimes not made explicit. As a result, communication of useful information between the design team and the building users and managers sometimes does not occur.

4. Building Operations were Complex

Some buildings had numerous operation and control options, each of which was only appropriate for limited situations. The complexity sometimes overwhelmed unsophisticated users.

5. Appropriate Actions were Unfamiliar

When correct building operation depended on users doing actions that were unfamiliar, they often either did not perform the actions or performed them incorrectly.

6. Relationship Between Operational Actions and Comfort Was Too Indirect

Users sometimes could not understand the relationship between the actions they were supposed to take and comfort conditions. This occurred either because the effects were indirect or because the actions seemed counter-intuitive to them (e.g. closing glass fireplace doors to keep the building warmer).

7. Following Instructions Did Not Result in Comfortable Conditions.

In these situations, building occupants tried a variety of other means to achieve comfort. These included adding portable electric heaters, fans and lights to acheive thermal comfort and blocking off windows and skylights to reduce heat gain, darken a room or achieve privacy.

8. Operations Which Solved One Comfort Problem Contributed to a Different Comfort Problem

In several cases, glare control devices, solar gain controls and ventilation systems were poorly combined. As a result, user attempts to control thermal problems interfered with the ventilation strategy, attempts to control ventilation caused problems with the lighting strategy etc.

D. PASSIVE SOLAR DESIGN ISSUES--DAYLIGHTING

Daylighting solutions in these buildings saved energy while contributing to comfortable lighting conditions. Daylighting was used as a passive design strategy in all buildings in the program and relied on heavily in over half of them. Six types of daylighting solutions were used : Windows to reduce artificial lighting needs (78%) of buildings, Lightshelves (48% of buildings), Clerestories (39% of buildings), Roof monitors (35% of buildings), Sunspace and borrowed light (13% of buildings), and Skylights (13% of buildings). (A clerestory is defined as an upper zone of a wall pierced with a window to admit light or air. A roof monitor is defined as a raised section of roof with openings, louvers, or windows (not parallel to roof plane) used to admit light or air). This section summarizes the experiences associated with these daylighting strategies.

The buildings illustrate good basic solutions to daylighting which could be used successfully in other buildings.

1. Daylighting Resulted in Significant Cost and Energy Savings While Contributing to User Comfort.

Approximately 55% savings over base case lighting energy use was achieved through the use of these daylighting strategies.

These energy savings, discussed in greater detail in an earlier section, were NOT achieved 'at the expense of' either energy use for heating or cooling or of user comfort.

2. Occupant Satisfaction with the Lighting Environment was Quite High.

Daylight is a principal contributor to the increased amenity of passive buildings. Fewer than 5% of occupants complained about 'too dim' or 'too bright' conditions, across all buildings and types of daylighting design. The many spontaneous comments about the delightful qualities of the daylighting attest to user satisfaction with this aspect of the buildings.

Some occupants commented on the delight of knowing when clouds were passing just by the change in daylighting quality. In some buildings, users who were initially concerned about the adequacy of the daylighting became more satisfied as they "got used to it" and its variable, dynamic quality. This challenges the assumption that occupants want unchanging "perfect" lighting conditions.

3. Successful Daylighting Designs Shared a Number of Characteristics.

The most important aspect of the successful use of daylighting was distribution. If daylight was well distributed, a visually comfortable, and largely glare free environment was attained. The design solutions which were most successful had the following characteristics:

- Glare and contrast were controlled. Beam daylighting was not allowed to directly enter an occupied space. Baffles, diffusing reflecting surfaces, and/or diffusing glazing were used to break up beam lighting. Occupants were not able to directly see the light source from the spaces they usually occupied.

- Light was admitted into the space high on the wall plane or at the ceiling plane.

- The view was retained.

- A number of smaller roof apertures (clerestories and roof monitors) were used rather than a few large openings.

- All roof monitors were designed with South facing glazing.

- Perimeter lighting through the combination of windows and light shelves was expensive and did not demonstrate greater energy savings than did overhead lighting systems.

4. Daylighting Provided Ambient Lighting in Most Buildings.

In most buildings, daylight provided ambient or background illumination, with artificial lighting used to provide task specific lighting. In three buildings, however, the Mt. Airy Library, Wells Security State Bank and St. Mary's School Gymnasium, daylight provided the majority of the required task lighting.

Although artificial lighting systems were available to supplement natural lighting, users reported that daylighting alone was often sufficient to illuminate their normal activities. Where roof apertures were used (roof monitors and clerestories), there were fewer complaints about glare than where the daylighting source was on the perimeter (windows, with or without light shelves).

5. Manual Controls for Artificial Lighting can be Operated Successfully by Building Occupants.

Correct manual lighting control can result in both energy savings and acceptable lighting levels. Special studies carried out by Lawrence Berkeley Laboratory (Andersson et al, 1984) concluded that in the two buildings which were studied in depth, users operated manual lighting controls in a more energy efficient manner than simple automated control systems would have under the same occupancy conditions. One reason for these results is that occupants were satisfied at illumination levels lower than those which industry standards recommend (and which automated control systems use), even when they had the option to increase those lighting levels. Although this is insufficient evidence on which to draw general conclusions, it does indicate that occupants can use lighting controls

effectively under some conditions. This finding, although only in the two buildings which have been analyzed in detail, seems to substantiate other recent findings about occupant control of artifical lighting (Robertson, 1984).

6. Integration of Daylighting and Artificial Lighting can be Successful.

Some users admitted using artificial lights even when they knew that natural lighting would have been sufficient. Despite the fact that building users can operate manual controls to save energy while achieving comfort, many building users turn on the lights almost automatically at the beginning of the work day irrespective of the illumination requirments. It may be that this is symbolic - signifying "I am open for business and ready to work." Once lights have been turned on, people tend not to turn them off. It is interesting to speculate on possible substitute symbolic ways to announce readiness for work which are less energy consuming than turning on the lights.

A number of the buildings successfully integrated daylighting and artificial lighting. The most successful integrations occurred when:

- Switching of any kind was unnecessary for extended periods (e.g. whole days)
- Variations in distribution of daylight could be supplemented according to need in the space by zoned switching
- Zones were laid out parallel to the daylight source rather than perpendicular to the daylight source
- Multilevel switching could supplement available daylight in a stepwise manner.

E. PASSIVE SOLAR DESIGN ISSUES --THERMAL MASS

Despite the fact that passive solar buildings are often thought of as depending on high mass solutions, the buildings in this program could be divided into three groups, each using a different type of thermal mass solution. High mass buildings, such as Mt. Airy, CUMC, Alaska Two Rivers School and Comal County, used amount and distribution of large amounts of thermal mass to store, delay and diffuse heat energy throughout the building. Another group of buildings used localized thermal mass (such as trombe walls), where the location of the mass was designed specifically to supply the heating/cooling energy needs of a particular area of the building. This group included Girl Scouts, St. Mary's Gym, Johnson Controls, RPI, CMC and Gunnison Airport. The third group of buildings used low mass design solutions, appropriate to their timing of occupancy, climate etc. Low mass buildings included Wells Bank, and Princeton Professional Park.

Analysis of energy, economic and occupancy issues has led to the following conclusions.

1. High Mass Does Not Appear to Have Been a Contributing Factor in the Energy Efficient Functioning of These Buildings

   High mass construction is not necessary to achieve significant energy savings. The effective use of mass depends on understanding the interrelationships among several factors: occupancy schedule, type of building use, the type of energy problem and the way mass is distributed throughout the space.

2. High Mass Does Not Necessarily Solve Thermal Comfort Problems, and in Some Cases Appears to Have Contributed to Problems.

   High mass solutions are often associated with these problems:

   - Acoustic - Exposed hard surfaces of thermal storage material cannot easily absorb sound
   - Thermal - Regulation of timing and amount of 'heat delivery to space' is difficult
   - Mechanical system integration - the mechanisms by which thermal mass is charged by mechanical systems and natural passive systems are not well understood.

Moderate amounts of well distributed thermal mass are apparently usually sufficient to solve thermal problems.

3. Localized Mass can be an Effective Strategy to Provide Delayed Heat to Specific Building Locations.

Several buildings successfully used localized thermal mass to provide comfort conditions, while saving energy at little incremental construction cost.

4. Several Low Mass Buildings Can Perform Well

As these buildings had daytime occupancy patterns, they required early morning warm up and had no need for delay of heat delivery to the space. The designs took advantage of direct gain strategies for heating. The Wells Security State Bank, for example, used little energy while providing comfortable conditions for building users.

F. PASSIVE SOLAR DESIGN ISSUES--NATURAL VENTILATION

Natural passive ventilation was used as an integral part of the cooling strategy in a number of buildings. While it is not possible to know exactly how well the natural ventilation systems performed, some problems with various approaches can be identified.

1. Assumptions About Air Currents Were Sometimes Inaccurate.

A number of designer assumptions about the paths that interior ventilative currents would take in order to effectively cool and/or ventilate the space were found to be inaccurate. Particularly, when currents were assumed to turn corners or travel along indirect pathways to create comfortable conditions and save energy, these expectations were not substantiated.

2. Conflict Between Shading Devices and Apertures Impeded Ventilative Flows.

A variety of sources of natural ventilation were employed in the buildings, usually in the form of an operable window or door. In order to be effective, these sources had to remain unobstructed. However, in a number of buildings, shading devices were being used over these ventilation sources, impeding the inflow of air. These shading devices were being for:

- Glare control
- Darkening of space to show slides or films
- Solar gain control

3. Manually Operated Ventilation Control Strategies Can Work.

Controls are most effective when they are familiar, close to the affected user and simple to understand and operate.

Andersson, Brandt et al., "Effect of Daylighting Options on the Energy Performance of Two Existing Passive Commercial Buildings, LBL Report LBL-18069, Berkeley, CA, September, 1984.

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

TOTALS

%/#	1981	1982	1983	1984	1985	GRAND TOTAL
RESPONDENTS	3	179	204	214	16	616
DISCOMFORT INDEX	--	27/48	22/44	40/55	NA	28/147
TOO HOT	--	37/66	25/52	37/79	13/2	32/199
Majority Time	--	--	--	--	--	--
TOO COOL	--	41/73	36/73	46/99	19/3	40/248
Majority Time	--	--	--	--	--	--
TOO DRAFTY:						
Occasionally	--	8/14	15/31	22/28	25/4	15/77
Frequently	--	2/4	10/20	9/12	--	7/36
TOO STUFFY:						
Occasionally	--	22/40	12/25	30/38	25/4	21/107
Frequently	--	9/16	9/19	9/11	--	9/46
TOO SMOKEY:						
Occasionally	--	12/22	12/24	12/16	13/2	12/64
Frequently	--	3/5	10/20	5/6	--	6/31
ARTIFICIAL LIGHT:						
Too Bright	--	9/16	9/18	.01/1	44/7	8/42
Too Dim	--	8/14	13/26	4/5	6/1	9/46

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)
TOTALS

%/#	1981	1982	1983	1984	1985	GRAND TOTAL
NATURAL LIGHT:						
Too Bright	--	6/10	12/25	9/20	44/7	10/62
Time	--	--	--	--	--	--
Too Dim	--	26/46	25/52	10/22	6/1	20/121
Time	--	--	--	--	--	--
TOO MUCH GLARE						
Occasionally	--	17/32	11/23	14/31	9/14	16/98
Frequently	--	8/15	8/17	3/6	--	6/38
USE LIGHTS WHEN DON'T NEED TO	66/2	18/33	27/56	9/22	NA	23/113
TOO LITTLE PRIVACY	--	23/42	33/61	45/56	NA	32/159
NOISE PROBLEMS						
Conversation:						
Occasionally	--	27/49	23/46	22/28	--	23/123
Frequently	--	8/15	14/29	11/14	--	11/58
Telephone:						
Occasionally	--	27/49	21/43	26/34	6/1	24/127
Frequently	--	11/20	13/27	8/11	--	11/58
Concentrate:						
Occasionally	--	27/48	18/36	21/27	--	21/111
Frequently	--	7/12	13/26	8/10	--	9/48
Sound Disturbances:						
Occasionally	--	17/24	23/42	35/45	--	24/111
Frequently	--	10/14	14/26	8/10	--	11/50
Overall Satisfaction (average points 1 - 6)	5	4.0	4.0	3.7	NA	3.95

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

%/#	Jan '81	Feb '81	Mar '81	TOTAL
RESPONDENTS	1	1	1	3
DISCOMFORT INDEX	--	--	--	--
TOO HOT	--	--	--	--
Majority Time	--	--	--	--
TOO COOL	--	--	--	--
Majority Time	--	--	--	--
TOO DRAFTY:				
Occasionally	--	--	--	--
Frequently	--	--	--	--
TOO STUFFY:				
Occasionally	--	--	--	--
Frequently	--	--	--	--
TOO SMOKEY:				
Occasionally	--	--	--	--
Frequently	--	--	--	--
ARTIFICIAL LIGHT:				
Too Bright	--	--	--	--
Too Dim	--	--	--	--

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)

%/#	Jan '81	Feb '81	Mar '81	TOTAL
NATURAL LIGHT:				
Too Bright	--	--	--	--
Time	--	--	--	--
Too Dim	--	--	--	--
Time	--	--	--	--
TOO MUCH GLARE				
Occasionally	--	--	--	--
Frequently	--	--	--	--
USE LIGHTS WHEN DON'T NEED TO	--	100/1	100/	66/2
TOO LITTLE PRIVACY	--	--	--	--
NOISE PROBLEMS				
Conversation:				
Occasionally	--	--	--	--
Frequently	--	--	--	--
Telephone:				
Occasionally	--	--	--	--
Frequently	--	--	--	--
Concentrate:				
Occasionally	--	--	--	--
Frequently	--	--	--	--
Sound Disturbances:				
Occasionally	--	--	--	--
Frequently	--	--	--	--
Overall Satisfaction (average points 1 - 6)	5	5	5	5

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

%/#	Jan '82	Feb '82	Mar '82	Apr '82	May '82	June '82
RESPONDENTS	1	1	2	3	18	28
DISCOMFORT INDEX	--	--	50/1	--	17/3	21/6
TOO HOT	--	--	--	--	22/4	36/10
Majority Time	--	--	--	--	AM/AFT	AFT
TOO COOL	100/1	100/1	100/2	100/3	50/9	29/8
Majority Time	AM	AM	AM	AM	AM	AM
TOO DRAFTY:						
Occasionally	--	--	--	--	5/1	4/1
Frequently	--	--	--	--	11/2	--
TOO STUFFY:						
Occasionally	--	--	--	--	22/4	21/6
Frequently	--	--	--	--	17/3	7/2
TOO SMOKEY:						
Occasionally	--	--	--	--	28/5	7/2
Frequently	--	--	--	--	--	4/1
ARTIFICIAL LIGHT:						
Too Bright	--	--	--	--	11/2	--
Too Dim	--	--	--	--	5/1	4/1

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

%/#	July '82	Aug '82	Sept '82	Oct '82	Nov '82	Dec '82	TOTAL
	19	17	25	17	11	37	179
	37/7	29/5	12/3	41/7	36/4	32/12	27/48
	79/15	82/14	36/9	53/9	27/3	5/2	37/66
	AFT	AFT	AFT	AFT	AFT	AM/AFT	--
	10/2	18/3	8/2	41/7	73/8	73/27	41/73
	AM	AM	AM	AM	AM	AM	--
	5/1 --	18/3 6/1	-- --	18/3 --	27/3 9/1	5/2 --	8/14 2/4
	58/11 16/3	41/7 12/2	20/5 4/1	12/2 29/5	-- --	14/5 3/1	22/40 9/16
	32/6 --	18/3 --	8/2 --	12/2 12/2	9/1 --	3/1 5/2	12/22 3/5
	11/2	6/1	4/1	24/4	18/2	11/4	9/16
	--	6/1	--	18/3	9/1	19/7	8/14

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)

%/#	Jan '82	Feb '82	Mar '82	Apr '82	May '82	June '82
NATURAL LIGHT:						
Too Bright	--	--	--	--	22/4	11/3
Time	--	--	--	--	AFT	AFT
Too Dim	--	--	--	66/2	28/5	21/6
Time	--	--	--	AM/AFT	AFT	AFT
TOO MUCH GLARE						
Occasionally	--	--	--	--	17/3	29/8
Frequently	--	--	--	--	17/3	11/3
USE LIGHTS WHEN DON'T NEED TO	--	--	100/2	66/2	22/4	4/1
TOO LITTLE PRIVACY	--	--	--	33/1	33/6	36/10
NOISE PROBLEMS						
Conversation:						
Occasionally	--	--	--	--	17/3	18/5
Frequently	--	--	--	--	11/2	7/2
Telephone:						
Occasionally	--	--	--	--	33/6	32/9
Frequently	--	--	--	--	17/3	7/2
Concentrate:						
Occasionally	--	--	--	--	28/5	29/8
Frequently	--	--	--	--	6/1	7/2
Sound Disturbances:					**	**
Occasionally	--	--	--	--	2/2	18/3
Frequently	--	--	--	--	2/2	--
Overall Satisfaction (average points 1 - 6)	5*	5*	5*	5*	4.8**	4.8**

* Only 14 of 15 buildings included
** Only 13 of 15 buildings included

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)

Z/#	July '82	Aug '82	Sept '82	Oct '82	Nov '82	Dec '82	TOTAL
	-- --	6/1 AFT	-- --	11/2 AM	-- --	-- --	6/10
	42/8 AFT	29/5 AFT	16/4 AM/AFT	24/4 AM/AFT	36/4 AM/AFT	22/8 AM	26/46
	21/4 --	11/2 6/1	4/1 4/1	11/2 18/3	36/4 9/1	16/6 8/3	17/32 8/15
	21/4	11/2	16/4	41/7	27/3	11/4	18/33
	21/4	24/4	20/5	24/4	9/1	19/7	23/42
	53/11 11/2	59/10 --	28/7 --	18/3 18/3	27/3 18/2	22/8 11/4	27/49 8/15
	47/9 21/4	59/10 11/2	20/5 4/1	11/2 24/4	18/2 18/2	16/6 5/2	27/49 11/20
	37/7 16/3	29/5 6/1	28/7 --	24/4 18/3	36/4 9/1	22/8 5/2	27/48 7/12
	22/2 11/1	13/1 13/1	24/6 4/1	18/3 18/3	18/2 9/1	14/5 14/5	17/24 10/14
	4.8**	4.0**	4.8*	4.0*	3.8*	4.4*	4.0**

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

%/#	Jan '83	Feb '83	Mar '83	Apr '83	May '83	June'83
RESPONDENTS	11	18	32	17	9	8
DISCOMFORT INDEX	36/4	22/4	13/4	6/1	11/1	--
TOO HOT	--	6/1	16/5	18/3	22/2	50/4
Majority Time	--	AFT	AFT	AFT	AFT	AFT
TOO COOL	73/8	44/8	34/11	41/7	11/1	--
Majority Time	AM	AM	AM	AM	AM	--
TOO DRAFTY:						
Occasionally	18/2	17/3	9/3	29/5	11/1	--
Frequently	9/1	11/2	7/2	6/1	--	--
TOO STUFFY:						
Occasionally	--	11/2	7/2	18/3	--	25/2
Frequently	18/2	--	7/2	6/1	--	--
TOO SMOKEY:						
Occasionally	9/1	6/1	3/1	6/1	--	--
Frequently	9/1	6/1	7/2	12/2	11/1	--
ARTIFICIAL LIGHT:						
Too Bright	--	6/1	9/3	12/2	--	--
Too Dim	27/3	22/4	13/4	29/5	33/3	25/2

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

%/#	July '83	Aug '83	Sept '83	Oct '83	Nov '83	Dec '83	TOTAL
	4	27	0	47	9	21	204
	--	48/13	--	11/5	33/3	43/9	22/44
	75/3	88/24	--	15/7	11/1	9/2	25/52
	AFT	AFT	--	AFT	--	AFT	--
	--	11/3	--	34/16	67/6	62/13	36/73
	--	AM	--	AM	AM	EVE	--
	--	26/7	--	13/6	44/4	--	15/31
	--	15/4	--	15/7	33/3	--	10/20
	25/1	22/6	--	17/8	11/1	--	12/25
	--	33/9	--	15/7	--	--	9/19
	--	33/9	--	21/10	11/1	--	12/24
	25/1	26/7	--	11/5	--	--	10/20
	--	37/10	--	2/1	11/1	--	9/18
	50/2	--	--	6/3	--	--	13/26

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)

%/#	Jan '83	Feb '83	Mar '83	Apr '83	May '83	June'83
NATURAL LIGHT:						
Too Bright	--	11/2	9/3	18/3	11/1	--
Time	--	AM	AFT	AFT	AM	--
Too Dim	45/5	50/9	19/6	41/7	--	50/4
Time	AM/AFT	AM/AFT	AM	AM	--	AM/AFT
TOO MUCH GLARE						
Occasionally	--	22/4	16/5	12/2	--	--
Frequently	9/1	--	3/1	29/5	11/1	--
USE LIGHTS WHEN DON'T NEED TO	36/4	33/6	13/4	12/2	--	25/2
TOO LITTLE PRIVACY	9/1	17/3	28/9	35/6	11/1	38/3
NOISE PROBLEMS						
Conversation:						
Occasionally	45/5	11/2	25/8	35/6	11/1	13/1
Frequently	9/1	28/5	13/4	18/3	11/1	--
Telephone:						
Occasionally	36/4	11/2	25/8	24/4	56/5	--
Frequently	9/1	28/5	16/5	24/4	11/1	13/1
Concentrate:						
Occasionally	45/5	11/2	19/6	18/3	11/1	25/2
Frequently	9/1	22/4	16/5	24/4	11/1	--
Sound Disturbances:						
Occasionally	27/3	11/2*	22/7*	18/3	67/6	25/2
Frequently	9/1	22/4	16/5	29/5	11/1	--
Overall Satisfaction (average points 1 - 6)	4.0	4.2*	4.4*	3.9	3.0	4.0

* Only 14 of 15 buildings included

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)

%/#	July '83	Aug '83	Sept '83	Oct '83	Nov '83	Dec'83	TOTAL
	25/1 AM	7/2 --	-- --	8/4 AM	78/7 --	10/2 ALL DAY	12/25 --
	-- --	30/8 AM/AFT	-- --	19/9 AM	-- --	19/4 ALL DAY	25/52 --
	25/1 --	19/5 4/1	-- --	4/2 13/6	11/1 --	14/3 10/2	11/23 8/17
	--	67/18	100/1	34/16	33/3	--	27/56
	25/1	48/13	100/1	30/14	56/5	19/4*	33/61
	25/1 25/1	33/9 26/7	-- --	21/10 13/6	33/3 11/1	-- --	23/46 14/29
	25/1 25/1	67/8 15/4	-- --	17/8 11/5	33/3 --	-- --	21/43 13/27
	-- 25/1	26/7 22/6	-- --	15/7 6/3	33/3 11/1	-- --	18/36 13/26
	25/1 25/1	19/5 22/6	-- --	13/6* 6/3	33/3 --	19/4* --	23/42 14/26
	4.3	4.0	3.0	3.9*	4.1	4.0*	4.0*

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

%/#	Jan '84	Feb '84	Mar '84	Apr '84	May '84	June '84
RESPONDENTS	30	35	32	34	35	20
DISCOMFORT INDEX	43/10*	41/13*	20/6*	15/5*	17/6	25/5
TOO HOT	13/4	11/4	22/7	53/18	69/24	5/1
Majority Time	AFT	ALL	AFT	AFT	AFT	ALL
TOO COOL	53/16	6/21	66/21	44/15	25/9	6/12
Majority Time	EVE	EVE	EVE	AM	AFT	AM
TOO DRAFTY:	*	*	*	*	*	
Occasionally	31/4	22/4	5/7	12/2	22/4	2/3
Frequently	8/1	11/2	6/1	6/1	17/3	2/4
TOO STUFFY:	*	*	*	*	*	
Occasionally	8/1	22/4	4/6	35/6	44/8	3/6
Frequently	--	--	--	--	22/4	5/1
TOO SMOKEY:	*	*	*	*	*	
Occasionally	--	11/2	2/3	18/3	28/5	--
Frequently	8/1	11/2	6/1	--	6/1	5/1
ARTIFICIAL LIGHT:	*	*	*		*	
Too Bright	8/1	22/4	6/1	--	28/5	1/2
Too Dim	--	--	--	--	--	2/3

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

%/#	July '84	Aug '84	Sept '84	Oct '84	Nov '84	Dec '84	TOTAL
	2	9	7	1	4	5	2/4
	--	78/7	14/1	--	50/2	--	40/55
	50/1	100/9	71/5	100/1	100/4	20/1	37/79
	AM	AFT	AFT	AFT	AFT	AFT	--
	50/1	11/1	--	--	--	60/3	46/99
	AM	AM	--	--	--	AM	--
	50/1	--	--	--	50/2	20/1	22/28
	--	--	--	--	--	--	9/12
	--	44/4	14/1	--	25/1	20/1	30/38
	--	33/3	14/1	--	50/2	--	9/11
	--	22/2	--	--	25/1	--	12/16
	--	--	--	--	--	--	5/6
	--	11/1	--	--	--	--	.01/1
	--	22/2	--	--	--	--	4/5

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)

%/#	Jan '84	Feb '84	Mar '84	Apr '84	May '84	June '84
NATURAL LIGHT:		*	*	*		
Too Bright	--	6/2	13/4	3/1	--	30/6
Time	--	--	AM/AFT	--	--	AM
Too Dim	4/1 *	19/6 *	3/1 *	6/2 *	14/5	10/2
Time	--	--	AFT	AFT	AM	AM/AFT
TOO MUCH GLARE						
Occasionally	7/2	9/3	10/3	6/2	29/10	25/5
Frequently	--*	--*	6/2*	3/1*	--	10/2
USE LIGHTS WHEN DON'T NEED TO	17/1**	27/4**	--	13/2**	27/5*	5/1
TOO LITTLE PRIVACY	67/4**	67/10**	69/9**	4/6**	55/10	20/4
NOISE PROBLEMS						
Conversation:	*	*	*	*	*	
Occasionally	38/5	33/6	13/2	18/3	22/4	5/1
Frequently	8/1	11/2	--	12/2	22/4	5/1
Telephone:	*	*	*	*	*	
Occasionally	38/5	44/8	6/1	24/4	28/5	20/4
Frequently	8/1	17/3	--	6/1	11/2	5/1
Concentrate:	**	*	*	*	*	
Occasionally	23/3	33/6	33/5	6/1	44/8	10/2
Frequently	--	17/3	--	12/2	17/3	5/1
Sound Disturbances:	*	*	*	*	*	
Occasionally	38/5	72/13	33/5	24/4	44/8	10/2
Frequently	8/1	11/2	7/1	12/2	17/3	--
Overall Satisfaction (average points 1 - 6)	4.6**	3.9**	3.6**	3.8**	3.5*	3.4

* Only 14 of 15 buildings included
** Only 13 of 15 buildings included

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)

%/#	July '84	Aug '84	Sept '84	Oct '84	Nov '84	Dec '84	TOTAL
	50/1 AFT	22/2 ALL	14/1 AM	-- --	50/2 AFT	20/1 AFT	9/20 --
	-- --	22/2 ALL	-- --	-- --	50/2 AFT	20/1 AFT	10/22 --
	-- --	11/1 --	42/3 --	-- --	25/1 25/1	20/1 --	14/31 3/6
	--	22/2	14/1	100/1	75/3	40/2	9/22
	50/1	33/3	42/3	100/1	75/3	40/2	45/56
	50/1 --	-- --	42/3 29/2	100/1 --	25/1 50/2	20/1 --	22/28 11/14
	-- --	33/3 --	29/2 14/1	100/1 --	-- 50/2	-- --	26/34 8/11
	-- --	11/1 --	-- --	100/1 --	-- 25/1	-- --	21/27 8/10
	-- --	22/2 --	29/2 14/1	100/1 --	50/2 --	20/1 --	35/45 8/10
	2.5	3	4.2	6	4.25	4.4	3.7

Table III - 1

SUMMARY OF FULL TIME USER RESPONSES

%/#	Jan '85
RESPONDENTS	16
DISCOMFORT INDEX	NA
TOO HOT	13/2
Majority Time	--
TOO COOL	19/3
Majority Time	--
TOO DRAFTY:	
Occasionally	25/4
Frequently	--
TOO STUFFY:	
Occasionally	25/4
Frequently	--
TOO SMOKEY:	
Occasionally	13/2
Frequently	--
ARTIFICIAL LIGHT:	
Too Bright	44/7
Too Dim	6/1

Table III - 1 - SUMMARY OF FULL TIME USER RESPONSES (continued)

% #	Jan '85
NATURAL LIGHT:	
Too Bright	44/7
Time	--
Too Dim	6/1
Time	--
TOO MUCH GLARE	
Occasionally	9/14
Frequently	--
USE LIGHTS WHEN DON'T NEED TO	NA
TOO LITTLE PRIVACY	NA
NOISE PROBLEMS	
onversation:	
Occasionally	--
Frequently	--
Telephone:	
Occasionally	6/1
Frequently	--
Concentrate:	
Occasionally	--
Frequently	--
Sound Disturbances:	
Occasionally	--
Frequently	--
Overall Satisfaction (average points 1 - 6)	NA

Table III - 2

SUMMARY OF PART TIME USER RESPONSE

TOTALS

	1981	1982	1983	1984	GRAND TOTAL
RESPONDENTS	3	82	72	77	234
THERMAL DISCOMFORT	33/1	13/11	18/13	22/17	18/42
Majority Time	--	--	--	--	--
STUFFY	--	12/10	6/4	10/8	9/22
Majority Time	--	--	--	--	--
DRAFTY	--	7/6	13/9	5/4	8/19
Majority Time	--	--	--	--	--
SMOKEY	--	4/3	--	3/2	2/5
Majority Time	--	--	--	--	--
GLARE	--	7/6	8/6	9/7	8/19
Majority Time	--	--	--	--	--
NOISY	--	21/17	31/22	13/10	21/49
Majority Time	--	--	--	--	--
LIGHT					
Dim	--	5/4	1/1	4/3	3/8
Bright	--	6/5	1/1	5/4	4/10

Table III - 2

SUMMARY OF PART TIME USER RESPONSE

%/#	Oct '81	Nov '81	Dec '81	TOTAL
RESPONDENTS	1	1	1	3
THERMAL DISCOMFORT	--	--	100/1	33/1
Majority Time	--	--	AFT	--
STUFFY	--	--	--	--
Majority Time	--	--	--	--
DRAFTY	--	--	--	--
Majority Time	--	--	--	--
SMOKEY	--	--	--	--
Majority Time	--	--	--	--
GLARE	--	--	--	--
Majority Time	--	--	--	--
NOISY	--	--	--	--
Majority Time	--	--	--	--
LIGHT	--	--	--	--
Dim	--	--	--	--
Bright	--	--	--	--

Table III - 2

SUMMARY OF PART TIME USER RESPONSE

%/#	Jan '82	Feb '82	Mar '82	Apr '82	May '82	June '82
RESPONDENTS	1	1	1	22	28	7
THERMAL DISCOMFORT	100/1	100/1	--	5/1	14/4	--
Majority Time	AFT	AM	--	--	AFT	--
STUFFY	--	--	--	5/1	14/4	--
Majority Time	--	--	--	--	AFT	--
DRAFTY	--	--	--	5/1	14/4	--
Majority Time	--	--	--	AM	--	--
SMOKEY	--	--	--	--	7/2	--
Majority Time	--	--	--	--	--	--
GLARE	--	--	--	5/1	11/3	14/1
Majority Time	--	--	--	AM	PM	AM
NOISY	--	--	--	18/4	21/6	43/3
Majority Time	--	--	--	AM	VARIOUS	AM
LIGHT						
Dim	--	--	--	14/3	--	14/1
Bright	--	--	--	--	14/4	--

Table III - 2 - SUMMARY OF PART TIME USER RESPONSE (continued)

%/#	July '82	Aug '82	Sept '82	Oct '82	Nov '82	Dec '82	TOTAL
	1	3	5	9	1	3	82
	--	66/2	--	11/1	--	22/1	13/11
	--	AFT	--	AM	--	AFT	--
	100/1	66/2	--	22/2	--	--	12/10
	AFT	--	--	AM	--	--	--
	--	--	--	11/1	--	--	7/6
	--	--	--	AM	--	--	--
	--	33/1	--	--	--	--	4/3
	--	AFT	--	--	--	--	--
	--	33/1	--	--	--	--	7/6
	--	PM	--	--	--	--	--
	--	--	--	44/4	--	--	21/17
	--	--	--	AM	--	--	--
	--	--	--	--	--	--	5/4
	--	22/1	--	--	--	--	6/5

Table III - 2

SUMMARY OF PART TIME USER RESPONSE

%/#	Jan '83	Feb '83	Mar '83	Apr '83	May '83	June '83
RESPONDENTS	9	17	17	5	8	3
THERMAL DISCOMFORT	11/1	6/1	6/1	--	--	66/2
Majority Time	AFT	PM	AFT	--	--	AM
STUFFY	--	--	12/2	--	--	66/2
Majority Time	--	--	AM	--	--	AM
DRAFTY	11/1	6/1	12/2	20/1	13/1	33/1
Majority Time	AM	AM	VARIOUS	AM	AM	AM
SMOKEY	--	--	--	--	--	--
Majority Time	--	--	--	--	--	--
GLARE	11/1	6/1	12/2	--	13/1	33/1
Majority Time	AM	AM	AM	--	AM	AM
NOISY	11/1	6/1	35/6	40/2	13/1	--
Majority Time	AM	AM	AM	AM	AM	--
LIGHT						
Dim	--	--	6/1	--	--	--
Bright	--	--	6/1	--	--	--

Table III - 2 - SUMMARY OF PART TIME USER RESPONSE (continued)

%/#	July '83	Aug '83	Sept '83	Oct '83	Nov '83	Dec '83	TOTAL
	--	--	1	4	4	4	72
	--	--	--	25/1	75/3	100/4	18/13
	--	--	--	AFT	AFT	AFT	--
	--	--	--	--	--	--	6/4
	--	--	--	--	--	--	--
	--	--	--	50/2	--	--	13/9
	--	--	--	AFT	--	--	--
	--	--	--	--	--	--	--
	--	--	--	--	--	--	--
	--	--	--	--	--	--	8/6
	--	--	--	--	--	--	--
	--	--	--	--	--	--	31/22
	--	--	--	--	--	--	--
	--	--	--	--	--	--	1/1
	--	--	--	--	--	--	1/1

Table III - 2

SUMMARY OF PART TIME USER RESPONSE

%/#	Jan '84	Feb '84	Mar '84	Apr '84	May '84	June '84
RESPONDENTS	5	10	18	11	9	7
THERMAL DISCOMFORT	--	1/1	22/4	36/4	33/3	29/2
Majority Time	--	AFT	AFT	VARIOUS	AM	AM
STUFFY	--	--	--	9/1	33/3	14/1
Majority Time	--	--	--	AM	AM	AM
DRAFTY	--	--	17/3	9/1	--	--
Majority Time	--	--	AFT	AM	--	--
SMOKEY	--	--	6/1	9/1	--	--
Majority Time	--	--	AFT	NOON	--	--
GLARE	--	--	17/3	9/1	11/1	--
Majority Time	--	--	AFT	NOON	AFT	--
NOISY	--	1/1	17/3	27/3	22/2	14/1
Majority Time	--	AFT	AFT	NOON	AM/AFT	AFT
LIGHT						
Dim	--	--	--	--	--	14/1
Bright	--	--	--	--	11/1	AFT

Table III - 2 - SUMMARY OF PART TIME USER RESPONSE (continued)

%/#	July '84	Aug '84	Sept '84	Oct '84	Nov '84	Dec '84	TOTAL
	3	3	5	2	3	1	77
	--	33/1	20/1	--	33/1	--	22/17
	--	AM	AFT	--	AM	--	--
	--	--	40/2	50/1	--	--	10/8
	--	--	--	--	--	--	--
	--	--	--	--	--	--	5/4
	--	--	--	--	--	--	--
	--	--	--	--	--	--	3/2
	--	--	--	--	--	--	--
	--	--	20/1	--	33/1	--	9/7
	--	--	AM	--	AM	--	--
	--	--	--	--	--	--	13/10
	--	--	--	--	--	--	--
	--	33/1	--	--	33/1	--	4/3
	--	--	40/2	50/1	AM	--	5/4

Table III - 3

SUMMARY OF
FULL TIME USER SATISFACTION RELATED RESPONSES

1. COMPARED TO OTHER BUILDINGS, LIKE APPEARANCE...		MORE	NEUTRAL	LESS
Does Fact It Is Solar	Yes	24/118	5/24	2/8
Influence	No	2/12	38/190	3/14

%/#

2. %/#	Overall Satisfaction		
	High	Mid	Low
Sedentary	11/52	7/32	1/5
Office Work	27/126	28/128	3/13
Walking	1/5	2/11	.01/3
Active	2/8	9/42	2/8
Male	27/224	10/85	1/14
Female	42/344	14/113	2/18
Less 12			
13-17	13/111	14/114	2/14
18-30	7/59	5/44	.004/3
31-45	5/42	4/31	.01/5
46-55	.01/4	.01/7	.002/2
56-65	56/446		
65+			
Yes	29/133	23/105	1/5
No (Orient.)	19/89	15/70	5/23

Table III - 4

SUMMARY OF
PART TIME USER SATISFACTION RELATED RESPONSES

COMPARED TO OTHER BUILDINGS, LIKE APPEARANCE...		MORE	NEUTRAL	LESS
Does Fact It Is Solar Influence %/#	Yes	26/58	3/7	2/4
	No	23/50	42/91	2/5

%/# DISCOMFORT	Thermal	Air Quality	Glare	Noise	Light
Sedentary	6/14	7/15	5/12	7/15	3/7
Standing	6/13	9/20	2/5	6/13	3/7
Walking	.005/1	.005/1			
Active	6/14	2/4	.005/1	.005/1	
Male	5/12	5/12	3/6	5/10	4/9
Female	14/31	12/26	5/12	9/19	2/5
Less 12				.005/1	
13-17				.005/1	
18-30	11/23	10/22	23/11	13/29	3/6
31-45	8/17	5/12	1/3	6/14	1/3
46-55	1/3	2/5	1/3	.005/1	1/2
56-65		.005/1	.005/1	.005/1	
65+					
Yes	15/32	16/34	7/16	7/16	5/11
No (Orient.)	3/7	2/4	.005/1	1/3	1/3

Total Respondents: 219

Respondents who have been to building 4 times in 3 months: 63/138

Thermal Comfort	Cool	Warm
Fall	1/3	1/3
Winter	11/24	1/3
Spring	6/14	1/3
Summer		2/4
Morning	12/27	2/4
Afternoon	5/11	2/5
Evening	2/4	.005/1

% Believe Control Comfort: 25/55

Designer Intended: 19/34**

% Who Do Control Comfort: 16/34

** Only 13 of 15 buildings included

APPENDIX I: ANALYSIS QUESTIONS/INFORMATIONAL INTERRELATIONSHIPS

INFORMATIONAL INTERRELATIONSHIPS

Number	Information Requested	Explanation	Related To Other Information	Number
	1.2000 ONE TIME - OCCUPANT RELATED INFORMATION			
1.2100 1.2110 1.2120 1.2130	Occupancy Assumptions Typical Weekday Typical Weekend Days with special occupancy patterns.	Change in number of of people and activity type influences ther- function of building and comfort levels. Need baseline for comparison.	Weekly occupancy profiles; monthly summaries	2.2110 2.2120 2.2130 3.2110 3.2120 3.2130
1.2200 1.2210 1.2220 1.2225	Operational Characteristics of Building Building operator/ maintenance staff Users. Expected variations	Thermal performance predictions are based on expected operational patterns. Need baseline for comparison. Compare with complaints, user reports of discomfort and interactions with building. Responsibility confusions often lead to dissatisfaction - specify here to clarify later. This section is basis for user manuals.	Operational Characteristics of Buildings - Staff Exceptions Unplanned actions Users: exceptions unplanned actions Summary of operational procedures User Questionnaire	2.2210 2.2211 2.2212 2.2221 2.2222 3.2200 3.2600

Number	Information Requested	Explanation	Related To Other Information	Number
1.2300	User Orientation Plans	Educated users may be more likely to operate building as predicted. Are user orientation programs correlated with users doing what designers expected?	User orientation programs	3.2300
			Operational procedures	1.2200
			User questionnaire	3.2600
	2.2000 WEEKLY OCCUPANT RELATED INFORMATION			
	Occupancy Profile	Weekly forms to be used as basis for monthly totals, to facilitate filling out 3.2110, 3.2120, 3.2130.	Occupancy assumptions	
2.2110	Weekday		Weekday	1.2110
2.2120	Weekend		Weekend	1.2120
2.2130	Days with special occupancy pattern		Days with special occupancy patterns	1.2130
			Expected Operational procedures	1.2200
2.2210	Operational Characteristics of Building Staff	Weekly collection of information on actual building operations by both staff and users reported by exceptions to expected operational procedures and unplanned actions taken to modify building or its use.		
2.2211	Exceptions			
2.2212	Unplanned actions taken			
2.2220	Operations - Building Users			
2.2221	Exceptions			
2.2222	Unplanned actions			

Number	Information Requested	Explanation	Related To Other Information	Number
2.2230	Maintenance Record	To record for comparison to actual energy use. Maintenance problems can influence energy use. Find out which devices or components have many problems. Accident record to address hazard concern in passive solar buildings (e.g., too much glare to see necessary contract? All the grazing? etc.) Summed monthly.	Actual energy use	3.1000
2.2240	Complaints Record	Systematically record types of problems by category and zone, look for patterns in troubleshooting.	User questionnaire	3.2600
	3.2000 MONTHLY OCCUPANT RELATED INFORMATION			
3.2100	Occupancy Profiles	Compare with expectations to check influence on thermal performance, including actual vs. allowable temperature levels. Compare with reported user ther-	Baseline occupancy assumptions	1.2110 1.2120 1.2130
3.2110	Weekday			
3.2120	Weekend			
3.2130	Days with special occupancy patterns			

Number	Information Requested	Explanation	Related To Other Information	Number
		Activity levels influence actual temperature and comfort.		
3.2200 3.2210 3.2220 3.2230 3.2240	Operational Characteristics Staff Users Maintenance Relevant complaints, comments and inquiries	To sum weekly building operations by exceptions to planned building use and by unplanned actions taken by staff and users. To compare with planned building operations and examine impact on energy use and user comfort. Relate to user orientation plans.	Operational Plans Staff Users User Orientation Plans	1.2210 1.2220 1.2300 3.2300
		Systematically summarize record of complaints, comments and inquiries. See patterns.	User questionnaire Complaints Comfort Operations	3.2600
3.2300	User Orientation	Does participation in a program mean you do the operations the designer expected? Do the users and operators agree on who does what to the building? Do users and operators agree whether user orientation programs	User Operations User Questionnaire Designer Operational Expectation	2.2220 3.2600 1.2300 1.2220

Number	Information Requested	Explanation	Related To Other Information	Number
3.2400	Context	Changes in each of these context concerns can influence actual energy use or the way it is recorded and/or reported. When analyzing comparisons between predicted and actual energy use it will be important to know if any context changes occurred.	Comparisons between predicted and actual energy use	3.3000
3.2410	Owner			
3.2420	Tenant			
3.2430	Responsibility for building operations		Context originally described	1.2400
3.2440	Responsibility for monitoring instrumentation			
3.2450	Responsibility for reporting data			
3.2460	Furniture			
3.2470	Location of activities			
3.2480	Permanent alterations			
3.2490	Temporary alterations			
3.2600	User Questionnaire	Regular opportunity to evaluate user comfort, satisfaction and interaction with the building.	—	
	Room in now	To correlate with zone for operational procedures, actual and allowable temperature and complaint records. Zone design relating to user thermal, acoustic, visual and air quality comfort perceptions.	Operational procedures	1.2200
			Complaint records	3.2240

Number	Information Requested	Explanation	Related To Other Information	Number
	User thermal comfort perceptions	Subjective comfort. relate to temperature set points, complaint record, triggering conditions in operational monthly record.	User comfort	3.2200
			Temperature set points	1.1800
			Complaint record	3.2240
			Clothing report	3.2600
			Operational records	3.2200
			Designer expectations	1.2210
			Operational responsibilities	1.2220
	User thermal comfort operations	"Educated" users will operate building more in accordance to designer/operator expectations. If uncomfortable, users will make changes, even if not supposed to. Since user comfort operations can influence energy use, need to record to compare with actual energy use patterns.	User orientation programs	3.2300
			User orientation self report	3.2600
			Actual energy use	3.1000
	User air quality perceptions	Do passive solar buildings have air quality problems? Relate to design.	Complaint record	3.2240
	User visual quality perceptions	Do passive solar buildings have visual quality problems? Relate to design.	Complaint record	3.2240

Number	Information Requested	Explanation	Related To Other Information	Number
		Do building operators and users perceive similar problems with visual environment?		
	User acoustic quality problems	Do passive solar buildings have perceived auditory problems? (Since properties of materials which absorb heat are different from properties of materials which absorb sound, acoustical problems might be encountered.)	Complaint record	3.2240
	User clothing worn	Do personal comfort control mechanisms (clothing) differ in passive solar buildings?		
	User gender and age	Are demographic descriptors correlated with perceived thermal, visual, acoustic or air quality comfort?	Thermal comfort Acoutic comfort Visual comfort Air quality comfort	3.2600 3.2600 3.2600 3.2600

Number	Information Requested	Explanation	Related To Other Information	Number
	Reported user orientation program participation	To compare with operator reports of participation by users. To relate to questions of user education and building operational procedures.	User orientation program plans User orientation programs Building operational procedures Building modifications	1.2300 3.2300 2.2220 3.2600
	User satisfaction	Are passive solar buildings acceptable to users? Are there age or sex differences? Is satisfaction related to knowledge?	User gender User age	3.2600 3.2600
	User activity	Are user reports of activity same as operator reports? Relate to comfort for comparison with occupancy expectation and monthly occupancy report.	Monthly occupancy Users therms, visual, acoustic comfort	1.2100 3.2600

APPENDIX II: REPORTING FORMS

1.1000: REQUIRED MEASUREMENTS - THERMAL PERFORMANCE EVALUATION

1.1800: ENVIRONMENTAL CONTROL SET POINTS (This Section to be completed for each thermal zone of the building, as designed.)

	1.1810 HEATING			1.1820 COOLING			1.1830 ECONOMIZER
	DAYTIME		NIGHT/WEEKENDS	DAYTIME		NIGHT/WEEKENDS	
ZONE	HOURS	SET POINT °F	SET POINT °F	HOURS	SET POINT °F	SET POINT °F	SET POINT °F
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			
	TO			TO			

** SEE TABLE 1.1 FOR EXPLANATORY NOTES **

1.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

1.2100: OCCUPANCY ASSUMPTIONS

1.2110: TYPICAL WEEKDAYS (Note: The expected occupancy of every zone for every month of the year should be explained. One form may be used to cover several months for a zone if applicable. Photo copy additional forms if needed.)

EXAMPLE

ROOMS INCLUDED IN THIS ZONE OFFICE SPACE

MONTH(S) _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

AM HOURS PM

NUMBER OF PEOPLE: 50 (9–6), 10 (6–10)

ACTIVITY CODE: 1 (9–6), 4 (6–10)

ALLOWABLE TEMPERATURE RANGE: 50° - 60° (9–6), 65°-70° (6–10), 60°-65 (6–10)

ROOMS INCLUDED IN THIS ZONE _____

MONTH(S) _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

AM HOURS PM

NUMBER OF PEOPLE _____

ACTIVITY CODE _____

ALLOWABLE TEMPERATURE RANGE _____

ACTIVITY CODE:
1. SEDENTARY - (SITTING, LISTENING)
2. STANDING
3. WALKING
4. ACTIVE - (RUNNING, PHYSICAL WORK, DANCING)

** SEE TABLE 1.2 FOR EXPLANATORY NOTES **

1.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

1.2100: OCCUPANCY ASSUMPTIONS

1.2120: TYPICAL WEEKEND (Note: The expected occupancy of every zone for every month of the year should be explained. One form may be used to cover several months for a zone if applicable. Photo copy additional forms if needed.)

EXAMPLE

ROOMS INCLUDED IN THIS ZONE COMMUNITY CENTER MULTI-PURPOSE ROOM
MONTH(S) _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
AM HOURS PM

25
NUMBER OF PEOPLE

3
ACTIVITY CODE

55°-60° 65°-75°
ALLOWABLE TEMPERATURE RANGE

ROOMS INCLUDED IN THIS ZONE _____
MONTH(S) _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
AM HOURS PM

NUMBER OF PEOPLE

ACTIVITY CODE

ALLOWABLE TEMPERATURE RANGE

ACTIVITY CODE:
1. SEDENTARY - (SITTING, LISTENING)
2. STANDING
3. WALKING
4. ACTIVE - (RUNNING, PHYSICAL WORK, DANCING)

** SEE TABLE 1.2 FOR EXPLANATORY NOTES **

1.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

1.2100: OCCUPANCY ASSUMPTIONS

1.2130: DAYS WITH SPECIAL OCCUPANCY PATTERNS
(For example, mid-week holidays, Fridays with extended hours. Photo copy additional forms as needed.)

ROOMS INCLUDED IN THIS ZONE BANK LOBBY
SPECIAL SITUATION _____ DATE _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
AM HOURS PM

4 — 15 — 4 — 20 — 2
NUMBER OF PEOPLE

2
ACTIVITY CODE

65°-70° — 65°-75° — 70°-75°
ALLOWABLE TEMPERATURE RANGE

EXAMPLE

ROOMS INCLUDED IN THIS ZONE _____
SPECIAL SITUATION _____ DATE _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
AM HOURS PM

NUMBER OF PEOPLE

ACTIVITY CODE

ALLOWABLE TEMPERATURE RANGE

ACTIVITY CODE:
1. SEDENTARY - (SITTING, LISTENING)
2. STANDING
3. WALKING
4. ACTIVE - (RUNNING, PHYSICAL WORK, DANCING)

** SEE TABLE 1.2 FOR EXPLANATORY NOTES **

1.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

1.2200: OPERATIONAL CHARACTERISTICS OF BUILDING

1.2210: BUILDING OPERATOR/MAINTENANCE STAFF (Operational instructions as would be described in a User/Operator's Manual. Photo copy additional pages if needed.)

	ACTION	TRIGGERING CONDITIONS (E.G., CHANGE IN COMFORT CONDITIONS, CHANGE IN SEASONS, ETC.)
EXAMPLE	ADJUST SHUTTER ANGLE	CHANGE OF SEASON FROM SUMMER TO WINTER
	COVER CLERESTORIES	SHOWING MOVIE IN DAYLIT SPACE
	LOWER THERMOSTAT FOR WEEKEND	WEEKEND
	DEPLOY SHADING DEVICE	SUNNY DAY SUDDEN RISE IN INSIDE TEMPERATURE

** SEE TABLE 1.2 FOR EXPLANATORY NOTES **

1.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

1.2200: OPERATIONAL CHARACTERISTICS OF BUILDING

1.2220: USERS (Operational instructions as would be described in a User Manual. Photo copy additional pages if needed.)

	ACTION	TRIGGERING CONDITIONS (E.G., CHANGE IN COMFORT CONDITIONS, CHANGE IN SEASONS, ETC.)
EXAMPLE	DO NOT PUT PLANTS ON LIGHT SHELVES	ALL TIMES
	CLOSE TROMBE WALL VENTS	OFFICE TOO WARM
	PUT ON EXTRA CLOTHING	CLASSROOM TOO COOL
	SWITCH ON FAN	ROOM STUFFY

** SEE TABLE 1.2 FOR EXPLANATORY NOTES **

1.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

1.2200: OPERATIONAL CHARACTERISTICS OF BUILDING

1.2225: IN MAKING ENERGY USE PREDICTIONS, DID YOU ASSUME CERTAIN VARIATIONS FROM THE OPERATIONAL INSTRUCTIONS GIVEN IN 1.2210 and 1.2220? (For example, 25% of the time, people will use artificial lights, when natural light is sufficient.)

_____

_____

_____

_____

1.2300: USER ORIENTATION PROGRAM PLANS

1.2310: USER GROUP _____

1.2320: SHORT DESCRIPTION _____

_____

1.2330: ARE BROCHURES, USER MATERIALS OR OTHER WRITTEN MATERIALS PLANNED?

_____ YES _____ NO

1.2340: HAVE THESE ALREADY BEEN PRODUCED?

_____ YES _____ NO

1.2350: PLANNED TIMING OR FREQUENCY OF USER ORIENTATION PROGRAMS

_____

1.2400: CONTEXT

1.2410: OWNER _____

1.2420: TENANT(S)

NAME	LOCATION

** SEE TABLE 1.2 FOR EXPLANATORY NOTES **

1.2 00: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

1.2400: CONTEXT (Continued)

1.2430: PERSON RESPONSIBLE FOR BUILDING OPERATION

_____

1.2440: PERSON RESPONSIBLE FOR MONITORING BUILDING INSTRUMENTATION

_____

1.2450: PERSON RESPONSIBLE FOR REPORTING DATA ON OCCUPANTY EVALUATION FORMS

_____

1.2500: DESIGN TOOL(S) USED IN MAKING ENERGY PREDICTIONS FOR THIS BUILDING

_____

_____

_____

1.2600: DID THE DESIGN TOOL USED GIVE THE MONTHLY ENERGY PREDICTIONS AS NOTED IN PREDICTED ENERGY USE TABLE (Section 1.1900)?

_____ YES _____ NO

IF NO, THEN HOW WERE MONTHLY PREDICTIONS DETERMINED?

_____

_____

_____

_____

** SEE TABLE 1.2 FOR EXPLANATORY NOTES **

2.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

2.2100: OCCUPANCY PROFILES

2.2110: TYPICAL WEEKDAY MONTH _____ WEEK _____

Has the occupancy profile varied significantly from that assumed in the one time measurement of occupancy profile in Section 1.2110?

_____ YES _____ NO

If yes, please complete the following for the zones where changes occurred. Photo copy this form for as many zones as necessary.

ROOMS INCLUDED IN THIS ZONE _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

AM HOURS PM

NUMBER OF PEOPLE

ACTIVITY CODE

ALLOWABLE TEMPERATURE RANGE

ROOMS INCLUDED IN THIS ZONE _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

AM HOURS PM

NUMBER OF PEOPLE

ACTIVITY CODE

ALLOWABLE TEMPERATURE RANGE

ACTIVITY CODE:
1. SEDENTARY - (SITTING, LISTENING)
2. STANDING
3. WALKING
4. ACTIVE - (RUNNING, PHYSICAL WORK, DANCING)

** SEE TABLE 2.2 FOR EXPLANATORY NOTES **

2.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

2.2100: OCCUPANCY PROFILES

2.2130: DAYS WITH SPECIAL OCCUPANCY PATTERNS
(For example, mid-week holidays, Fridays with extended hours. Photo copy additional forms as needed.)

ROOMS INCLUDED IN THIS ZONE _____
SPECIAL SITUATION _____ DATE _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
AM HOURS PM

NUMBER OF PEOPLE

ACTIVITY CODE

ALLOWABLE TEMPERATURE RANGE

ROOMS INCLUDED IN THIS ZONE _____
SPECIAL SITUATION _____ DATE _____

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
AM HOURS PM

NUMBER OF PEOPLE

ACTIVITY CODE

ALLOWABLE TEMPERATURE RANGE

ACTIVITY CODE:
1. SEDENTARY - (SITTING, LISTENING)
2. STANDING
3. WALKING
4. ACTIVE - (RUNNING, PHYSICAL WORK, DANCING)

** SEE TABLE 2.2 FOR EXPLANATORY NOTES **

2.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

2.2200: OPERATIONAL CHARACTERISTICS OF BUILDING (Please refer to One Time Measurements, Section 1.2200.)

WEEK _____

2.2210: BUILDING OPERATOR/MAINTENANCE STAFF (Please refer to Operational Instructions for Operators/Maintenance Staff, Section 1.2210.)

2.2211: DID STAFF ACT ACCORDING TO THE OPERATIONAL INSTRUCTIONS IN SECTION 1.2210? IF NOT, WHAT WERE THE VARIATIONS? (For example, shutter angle was not adjusted for changing season.)

_____

_____

2.2212: WHAT OTHER ENERGY ACTIONS DID THE BUILDING STAFF TAKE WHICH WERE NOT COVERED IN THE OPERATING INSTRUCTIONS (1.2220)? (For example, staff covering of skylights for slide/movie show.)

_____

_____

2.2220: USERS (Please refer to operational instructions for users, Section 1.2220.)

2.2221: DID USERS ACT ACCORDING TO THE OPERATIONAL INSTRUCTIONS IN SECTION 1.2320? IF NOT, WHAT WERE THE VARIATIONS? (For example, people putting plants on light shelves even though instructions prohibited it.)

_____

_____

2.2222: WHAT OTHER ENERGY-RELATED ACTIONS DID USERS TAKE WHICH WERE NOT COVERED IN THE OPERATING INSTRUCTIONS? (For example, employees making unauthorized adjustments to environmental controls.)

_____

_____

** SEE TABLE 2.2 FOR EXPLANATORY NOTES **

2.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

2.2200: OPERATIONAL CHARACTERISTICS OF BUILDING

2.2230: MAINTENANCE RECORD (Report energy system-related preventive maintenance and repairs, damage, etc.; don't report other miscellaneous maintenance such as light bulb replacement, or filter changes.)

	DATE REPORTED	TYPE OF PROBLEM	ROUTINE (R) OR UNUSUAL (U)	DATE FIXED
	2.2231	2.2232	2.2233	2.2234
EXAMPLE	1/4/82	CHANGED FAN BELT ON VENTILATING FAN	R	1/5/82
	1/5/82	GREASED INSULATING SHUTTER GEARS	R	1/6/82
	1/6/82	BROKEN SOUTH WINDOW	U	1/6/82
	1/7/82	LEAKY HOT WATER FAUCET	U	1/8/82

** SEE TABLE 2.2 FOR EXPLANATORY NOTES **

2.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

2.2200: OPERATIONAL CHARACTERISTICS OF BUILDING

2.2240: RELEVANT COMPLAINTS, COMMENTS, AND QUESTIONS RECORD

	DATE	TIME	LOCATION	CATEGORY*	USER DESCRIPTION
	2.2241	2.2242	2.2243	2.2244	2.2245
EXAMPLE	1/4/82	10 AM	LOBBY	1	RECEPTIONIST SAYS VERY COLD
	1/5/82	5 PM	NW OFFICE	3	OCCUPANT SAYS TOO MUCH GLARE
	1/6/82	5 PM	SE CLASSROOM	2	TEACHER SAYS NOISY FANS

*CATEGORIES: 1 = THERMAL; 2 = ACOUSTIC; 3 = VISUAL QUALITY; 4 = AIR QUALITY; 5 = OTHER

** SEE TABLE 2.2 FOR EXPLANATORY NOTES **

3.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

3.2200: OPERATIONAL CHARACTERISTICS OF BUILDINGS (Note: Program management team will summarize monthly building operational characteristics; no additional data is required from project teams for 3.2210, 3.220, 3.2230, and 3.2240.)

3.2210: OPERATOR/MAINTENANCE STAFF (Please attach weekly forms for the following.)

3.2220: USERS

3.2230: MAINTENANCE RECORD

3.2240: RELEVANT COMPLAINTS, COMMENTS, AND QUESTIONS RECORD

3.2300: USER ORIENTATION PROGRAMS - WERE USER ORIENTATION PROGRAMS HELD THIS MONTH? _____ YES _____ NO
(If needed, photo copy additional forms.)

3.2310: CATEGORIES OF USERS _____

3.2320: ONE SENTENCE DESCRIPTION OF THE PROGRAM _____

_____

3.2330: WERE HARD COPY MATERIALS DISTRIBUTED? _____ YES _____ NO
(If yes, please attach.)

3.2340: (Not applicable.)

3.2350: DATE OF PROGRAM _____

3.2400: CONTEXT

3.2410: WAS THERE A CHANGE IN OWNERSHIP? _____ YES _____ NO

3.2411: DATE OF CHANGE _____

3.2412: NAME OF NEW OWNER _____

3.2420: WAS THERE A CHANGE IN TENANTS? _____ YES _____ NO

3.2421: DATE OF CHANGE _____

3.2422: NAME OF NEW TENANTS AND THE SPACE THEY OCCUPY _____

_____

** SEE TABLE 3.2 FOR EXPLANATORY NOTES **

3.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

3.2400: CONTEXT (Continued)

3.2430: WAS THERE A CHANGE IN PERSON RESPONSIBLE FOR BUILDING OPERATION? _____ YES _____ NO

3.2431: DATE OF CHANGE _____

3.2432: NAME OF PERSON NOW RESPONSIBLE _____

3.2440: WAS THERE A CHANGE IN PERSON RESPONSIBLE FOR MONITORING BUILDING INSTRUMENTATION? _____ YES _____ NO

3.2441: DATE OF CHANGE _____

3.2442: NAME OF PERSON NOW RESPONSIBLE _____

3.2450: WAS THERE A CHANGE IN PERSON RESPONSIBLE FOR REPORTING DATA ON THESE FORMS? _____ YES _____ NO

3.2451: DATE OF CHANGE _____

3.2452: NAME OF PERSON NOW RESPONSIBLE _____

3.2460: WAS THERE A CHANGE IN FURNITURE OR OTHER LARGE ITEMS? _____ YES _____ NO

3.2461: DATE OF CHANGE _____

3.2462: NOTE NEW LOCATION _____

3.2463: NOTE PREVIOUS LOCATION _____

3.2470: WAS THERE A CHANGE IN LOCATION OF REGULAR ACTIVITY FROM ONE AREA TO ANOTHER? _____ YES _____ NO

3.2471: DATE OF CHANGE _____

3.2472: NOTE NEW LOCATION _____

3.2473: NOTE PREVIOUS LOCATION _____

3.2474: CHANGED ACTIVITY _____

** SEE TABLE 3.2 FOR EXPLANATORY NOTES **

3.2000: REQUIRED MEASUREMENTS - OCCUPANT PERFORMANCE EVALUATION

3.2400: CONTEXT (Continued)

3.2480: WERE THERE ANY PERMANENT ALTERATIONS WHICH MIGHT AFFECT ENERGY USE IN THE BUILDING? _____ YES _____ NO

3.2481: DATE PERMANENT ALTERATIONS BEGAN _____

3.2482: DESCRIBE ALTERATIONS _____

_____

3.2490: WERE THERE ANY TEMPORARY ALTERATIONS WHICH AFFECT ENERGY USE IN THE BUILDING? _____ YES _____ NO

3.2491: DATE TEMPORARY ALTERATIONS BEGAN _____

3.2492: PROJECTED/ACTUAL COMPLETION DATE _____

3.2493: DESCRIBE ALTERATIONS _____

_____

3.2500: DESIGN TOOLS (This category need not be filled out on a monthly basis.)

3.2600: USER QUESTIONNAIRES

3.2610: PLEASE NOTE THE NUMBER OF FULL-TIME USER QUESTIONNAIRES ATTACHED TO THIS REPORT _____

3.2620: PLEASE NOTE THE NUMBER OF PART-TIME USER QUESTIONNAIRES ATTACHED TO THIS REPORT _____

** SEE TABLE 3.2 FOR EXPLANATORY NOTES **

3.3000: COMPARISON WITH PREDICTIONS

3.3100: THERMAL PERFORMANCE

3.3110: PREDICTED VERSUS ACTUAL ENERGY CONSUMPTION TABLE

	ELECTRICITY			NATURAL GAS			FUEL OIL			OTHER			TOTAL		
	PREDICTED BTU	ACTUAL BTU	DELTA	PREDICTED BTU	ACTUAL BTU	DELTA	PREDICTED BTU	ACTUAL BTU	DELTA	PREDICTED BTU	ACTUAL BTU	DELTA	PREDICTED BTU	ACTUAL BTU	DELTA
SPACE HEATING															
DHW															
COOLING															
LIGHTING															
BLOWERS AND HVAC															
PASSIVE HYBRID															
MISC.															
TOTAL															

- PREDICTED BTUS: OBTAIN FROM TABLE 1.1900 FOR THE DESIRED MONTH
- ACTUAL BTUS: OBTAINED FROM TABLE 3.1700
- DELTA: ACTUAL BTUS - PREDICTED BTUS

3.3000: COMPARISON WITH PREDICTIONS

3.3200: POSSIBLE EXPLANATION FOR DISCREPANCIES

3.3210: IF YOU THINK THE DIFFERENCE BETWEEN PREDICTED AND ACTUAL ENERGY USE FOR THIS MONTH WAS SIGNIFICANTLY INFLUENCED BY CHANGED OCCUPANCY PATTERNS, PLEASE EXPLAIN BELOW

ZONE OR ROOM	PERIOD OF TIME FOR CHANGED OCCUPANCY	EXPLANATION
3.3211	3.3212	3.3213
ENTIRE BLDG.	CHRISTMAS WEEK	SCHOOL VACATION
CONFERENCE ROOM	2-12/2-28	ROOM BEING REDECORATED
CONFERENCE ROOM	2-2/2-12	OCCUPIED EVERYDAY FOR SPECIAL DAY LONG MEETINGS

EXAMPLE

3.3000: COMPARISON WITH PREDICTIONS

3.3200: POSSIBLE EXPLANATION FOR DISCREPANCIES

3.3220: IF YOU THINK THE DIFFERENCE BETWEEN PREDICTED AND ACTUAL ENERGY USE FOR THIS MONTH WAS SIGNIFICANTLY INFLUENCED BY CHANGED OPERATIONAL PROCEDURES, PLEASE EXPLAIN BELOW

	ZONE OR ROOM	PERIOD OF TIME FOR CHANGED OCCUPANCY	EXPLANATION
	3.3221	3.3222	3.3223
EXAMPLE	OFFICE BLDG.	1-3/1-20	OUTSIDE AIR DAMPER MALFUNCTIONED
	LIBRARY	11-4/11-11	EMPLOYEES BROUGHT IN AND USED PORTABLE ELECTRIC HEATERS WITHOUT AUTHORIZATION

3.3000: COMPARISON WITH PREDICTIONS

3.3200: POSSIBLE EXPLANATION FOR DISCREPANCIES

3.3230: OTHER POSSIBLE EXPLANATIONS FOR DISCREPANCIES BETWEEN EXPECTED AND ACTUAL ENERGY USE THIS MONTH

APPENDIX III: QUESTIONNAIRES

D.O.E. PASSIVE SOLAR COMMERCIAL BUILDINGS PROGRAM

FULL-TIME USER QUESTIONNAIRE

This building has been specially designed with the help of the U.S. Department of Energy to save energy (and money) while maintaining comfort. Since many of the design ideas used in this building are new, we want to take a close look at how the building is working. As a user of the building, you can help us understand how the building is working by taking a few minutes to fill out this form. It should only take about 10 minutes to circle or note your responses. Please feel free to add any additional comments.

Thank you very much.

1. Date: _____

2. Where in the building do you usually spend the most time? _____
   (If you are not now in that place, what room are you in now? _____)

3. Think about the temperature in that place over the past month. How would you rate its comfort?

   Quite Uncomfortable | Slightly Uncomfortable | Acceptable | Quite Comfortable

4. In the past month, how often have you been too warm in that place?

   Never | Seldom | Occasionally | Frequently

If you have been too warm, when does it occur?

Morning | Afternoon | Evening

If you feel too warm, what do you do? (Write a number 1 next to the action you do first if you feel too warm, a number 2 next to the action you do second, and a 3 next to the third thing you do.)

____ It is NEVER too warm
____ Nothing
____ Open a window
____ Remove extra clothing
____ Switch on a fan
____ Turn off a light
____ Close a curtain, blind or window
____ Slow down your pace or take a break
____ Discuss your feelings with other people in the area
____ Request maintenance to adjust the cooling system
____ Move to another space
____ Other (Please describe) _____

5. In the past month, how often have you been too cool in that place?

Never | Seldom | Occasionally | Frequently

If you have been too cool, when does it occur?

Morning | Afternoon | Evening

If you feel too cool, what do you do? (Write a number 1 next to the action you do first if you feel too cool, a number 2 next to the action you do second and a 3 next to the third thing you do.)

_____ It is NEVER too cool
_____ Nothing
_____ Open a door
_____ Switch on a fan
_____ Request maintenance to adjust the cooling system
_____ Open a window
_____ Put on extra clothing
_____ Discuss your feelings with other people in the area
_____ Move to another space
_____ Other (Please describe)

_____

6. Can you adjust the thermostat in the area you are in? _____

_____

7. Do you recall it being too drafty, too stuffy, or too smoky at the place you spend most of your time? (Please check all three.)

Too Drafty?

Never | Seldom | Occasionally | Frequently

Too Stuffy?

Never | Seldom | Occasionally | Frequently

Too Smoky?

Never | Seldom | Occasionally | Frequently

8. Please describe any examples you recall of unwanted heat or cold which may have disturbed you in the past month (for example: draft from window or grille, heat from sun shining on desk, etc.)

_____

_____

THE QUESTIONS IN THIS SECTION ASK ABOUT THE ELECTRIC AND NATURAL LIGHTING IN THE PLACE IN THIS BUILDING WHERE YOU SPEND MOST OF YOUR TIME.

9. When the electric lights are on, how would you rate the brightness of the electric lighting in this area?

Too Bright | Too Dim | About Right | Not Sure

If the lighting is too dim or too bright, how often does that happen?

Seldom | Occasionally | Frequently

10. Is there a window near where you spend your time? ____ Yes ____ No

IF YES,

What direction does the window face?

____ North ____ South ____ East ____ West ____ Not sure

How would you rate the brightness of the natural lighting in your area? Please answer for both morning and afternoon.

In the Morning				In the Afternoon			
Too Bright	Too Dim	About Right	Not Sure	Too Bright	Too Dim	About Right	Not Sure

11. If it is too bright in the area where you spend time, what do you do?

____ It is NEVER too bright
____ Nothing
____ Move to another area
____ Request maintenance to make an adjustment
____ Close a curtain, blind or other window covering
____ Discuss your feelings with other people in the area
____ Other (Please describe)
_____

12. If it is too dim in the area where you spend your time, what do you do?

____ It is NEVER too dim
____ Nothing
____ Move to another area
____ Add a new lamp or light fixture
____ Discuss your feelings with other people in the area
____ Turn on more lights
____ Request maintenance to make an adjustment
____ Other (Please describe)
_____

13. Do you recall there being too much glare in the area where you spend time?

Never | Seldom | Occasionally | Frequently

IF YES,

When?

____ Morning
____ Afternoon

What is the source?

____ Natural lighting
____ Artificial lighting
____ Both

Comments _____

14. From where you usually are, what is the direction of the lighting?

Overhead | From behind me | From in front of me | From the side

15. Are there times when natural light alone is sufficient for activities?

_____

16. Are you able to turn off the electric lights when you want to? _____ Yes _____ No

IF YES,

How often do you turn off the electric lights when the natural light is sufficient for your activities?

Never | Seldom | Occasionally | Frequently

THE NEXT FEW QUESTIONS ASK ABOUT PRIVACY IN THE AREA WHERE YOU SPEND YOUR TIME. CIRCLE THE NUMBER THAT INDICATES HOW YOU FEEL.

17. How much visual privacy do you have?

Much too little. People see me and I see them much more than I'd like. — Plenty. I feel as private as I need to.

1 2 3 4 5 6

Comments _____

18. How often does the noise level make it difficult to:

Hold a private conversation?

Never | Seldom | Occasionally | Frequently

Hear a phone conversation?

Never | Seldom | Occasionally | Frequently

Concentrate?

Never | Seldom | Occasionally | Frequently

19. How often are you disturbed by hearing sounds you would rather not hear?

Never | Seldom | Occasionally | Frequently

If yes, what kind of sounds are they? _____

THE LAST FEW QUESTIONS CONCERN YOUR OVERALL FEELINGS ABOUT THE BUILDING.

20. Do you like the appearance of this building more, less or about the same as other buildings of this type (banks, schools, etc.)?

More | Less | About the same

Does the fact that this is a solar building influence your opinion?

Yes _____ No _____

21. How do you rate your overall satisfaction with this building?

Not at all satisfied, dislike it					Highly satisfied, love it
1	2	3	4	5	6

Comments _____

22. Which activity are you usually doing during the time you spend in this building?

Sedentary (Sitting, reading)	Office work, teaching, standing, etc.	Walking	Active (Running, physical work, dancing)

23. Think about the temperature right now in the room you are in. How comfortable is it for you?

quite uncomfortable	slightly uncomfortable	acceptable but not ideal	quite comfortable

24. Please check those items of clothing you are wearing now.

_____ Short sleeve shirt, blouse or dress
_____ Shorts
_____ Slacks or skirt
_____ Long sleeve shirt, blouse or dress
_____ Sweater, blazer or sport coat
_____ Jacket or coat
_____ Thermal underwear

25. What is your sex? _____ M _____ F

26. What is your age group?

_____ Under 12 years
_____ 13-17
_____ 18-30
_____ 31-45
_____ 46-55
_____ 56-65
_____ 66 or older

27. Have you ever participated in a user orientation program that explains how this building works?

_____ Yes _____ No

If yes, was this within the past month?

_____ Yes _____ No

28. In what ways is this solar building different from what you might have expected a solar building to be?

_____

_____

_____

29. Please add any other comments you have about the building.

_____

_____

_____

D.O.E. PASSIVE SOLAR COMMERCIAL BUILDINGS PROGRAM

PART-TIME USER QUESTIONNAIRE

This building has been specially designed with the help of the U.S. Department of Energy to save energy (and money) while maintaining comfort. Since many of the design ideas used in this building are new, we want to take a close look at how the building is working. As a user of the building, you can help us understand how the building is working by taking a few minutes to fill out this form. It should only take about 5 minutes to circle or note your responses. Please feel free to add any additional comments.

Thank you very much.

1. Date: _____ What time is it? _____

2. Which room of the building are you in right now? _____

3. How long have you been there?

   Less than 1/2 hour | 1-3 hours | More than 3 hours

4. How often do you come to this building?

   This is the first time | Less Than once a month | Two/three times a month | Once a week or more

5. How does the temperature feel to you right now?

   Too cool | Comfortable | Too warm

6. Compared to other buildings, does this one:

   Seem more stuffy to you? Yes ____ No ____
   Feel drafty to you? Yes ____ No ____
   Seem smoky to you? Yes ____ No ____
   Have a lot of glare? Yes ____ No ____
   Seem noisy to you? Yes ____ No ____

7. How would you rate the brightness of the light?

   Too dim | About right | Too bright

8. Are there electric lights on right now in addition to the natural light? Yes__ No__

9. Do you like the appearance of this building more, less, or about the same as other buildings of this type (Banks, Schools, etc.)?

   More | Less | About the same

   Does the fact that this is a solar building influence your opinion? Yes__ No__

10. Please check the type of activity you are doing during the time you spend in this building.

    Sedentary (e.g., sitting, reading, writing) | Standing, waiting in line, office work, teaching | Walking | Active (e.g., running, dancing, physical work)

11. Have you ever had any explanation of how this building works? Yes ____ No ____

12. Male ____ Female ____; What is your age group?

    ____ Under 12 years
    ____ 13-17
    ____ 18-30
    ____ 31-45
    ____ 45-55
    ____ 55-66
    ____ 66 or older

13. Please add any other comments on how you feel about being in this solar building.

    _____

    _____

IF YOU HAVE BEEN IN THIS BUILDING MORE THAN 4 TIMES IN THE LAST 3 MONTHS, PLEASE ANSWER THREE ADDITIONAL QUESTIONS ON THE OTHER SIDE:

14. Please circle the season: Fall (Sept., Oct., Nov.)

Winter (Dec., Jan., Feb.)

Spring (March, Apr., May)

Summer (June, July, Aug.)

15. During the time you have spent in this room of the building this season, was the temperature usually:

Comfortable Too cool Too warm

If too cool or warm, was it in the ____ Morning ____ Afternoon ____ Evening

16. Can you control the comfort _____ Yes _____ No _____ Don't know

If yes, how can you control comfort conditions (open windows, turn off a light, close a curtain, turn on a fan, etc.)? _____

_____

Have you done any of these things this season _____ Yes _____ No.

If yes, please describe: _____

_____

APPENDIX IV: MONTHLY SUMMARY FORMS

SUMMARY: Monthly Full Time User Questionnaire Responses

1. BUILDING _____ MONTH _____
2. RESPONDENTS _____ %HEAT ____ %COOL ____ %LIGHT ____ %OTHER _____
3. EXPLANATION FOR DISCREPANCY? _____
4. MEASUREMENTS: MAINTENANCE ____ COMPLAINTS ____ ORIENTATION ____ CONTEXT _____
_____
5. OCCUPANCY DIF. INFLUENCE ENERGY USE _____
_____
6. DID INDIVIDUAL USERS DO ANYTHING TO DIRECTLY INFLUENCE ENERGY USE? _____
7. DISCOMFORT INDEX(# FREQ. TOO HOT + # FREQ. TOO COLD/N) _____
8. % TOO HOT (OCC.+FREQ./N) ____ WERE A MAJORITY DURING SAME TIME DAY? ____
WHEN? _____ MAJ. SAME LOCATION? ____ WHERE? _____
WHAT DID DESIGNER EXPECT THEM TO DO? _____
WHAT % DID THAT? _____ WHAT % OF UNCOMFORTABLE DID THAT? _____
9. % TOO COOL(OCC.+FREQ./N) ____ WERE A MAJORITY DURING SAME TIME DAY? ____
WHEN? _____ MAY. SAME LOCATION? ____ WHERE? _____
WHAT DID DESIGNER EXPECT THEM TO DO? _____
WHAT % DID THAT? _____ WHAT % OF UNCOMFORTABLE DID THAT? _____
10. UNWANTED HEAT COMMENTS? _____
11. AIR QUALITY TOO DRAFTY TOO STUFFY TOO SMOKEY
%OCCURRENCE _____ _____ _____
%FREQUENTLY _____ _____ _____
12. LIGHTING TOO BRIGHT TOO DIM
%OCCURRENCE _____ _____ LOCATION _____
%FREQUENTLY _____ _____ % DO WHAT DESIGNER INTENDED? _____
13. TOO MUCH GLARE %? _____ LOCATION/TIME OF FREQ.? _____
%FREQ _____
14. % USING LIGHTS WHEN THEY DON'T NEED TO? _____ PREDICTED? _____
15. PRIVACY: % TOO LITTLE VISUAL (3 OR LESS OF 6) _____
COMMENTS? _____
16. NOISE DIFFICULTY: CONVERSATION PHONE CONCENTRATION
% OCCURRENCE _____ _____ _____
% FREQUENTLY _____ _____ _____
17. LIKE APPEARANCE? YES NEUTRAL NO
SOLAR INFLUENCE YES ____ ____ ____
NO ____ ____ ____

19. OVERALL SATISFACTION		HIGH	MID	LOW	18. THERMAL DISCOMFORT TOO HOT OR TOO COOL
ACTIVITY	SEDENTARY	____	____	____	____
	OFFICE	____	____	____	____
	WALKING	____	____	____	____
	ACTIVE	____	____	____	____
SEX.....	MALE	____	____	____	____
	FEMALE	____	____	____	____
AGE.....	LESS 12	____	____	____	____
	13-17	____	____	____	____
	18-30	____	____	____	____
	31-45	____	____	____	____
	46-55	____	____	____	____
	56-65	____	____	____	____
	MORE 66	____	____	____	____
ORIENTATION	YES	____	____	____	____
	NO	____	____	____	____

SUMMARY: Monthly Part Time User Questionnaire Responses

1.BUILDING_____ MONTH_____
2.RESPONDENTS____ %HEAT____ %COOL____ %LIGHT____ %OTHER_____
3.EXPLANATION FOR DISCREPANCY?_____
4.MEASUREMENTS:MAINTENANCE____ COMPLAINTS____ ORIENTATION____ CONTEXT_____
_____
5.OCCUPANCY DIF. INFLUENCE ENERGY USE_____
_____
6.DID INDIVIDUAL USERS DO ANYTHING TO DIRECTLY INFLUENCE ENERGY USE?
_____
7.THERMAL DISCOMFORT INDEX(#FREQ.TOO HOT + # FREQ.TOO COOL/N)_____
8.WERE MAJORITY DURING SAME TIME OF DAY?_____ WHEN?_____
9.WERE MAJORITY IN SAME PART OF BUILDINGS?____ WHERE?_____

10.%REPORTING IN BUILDING:

	AIR QUALITY			GLARE	NOISY
	STUFFY	DRAFTY	SMOKEY		
TIME OF MAJORITY	_____	_____	_____	_____	_____
LOCATION OF MAJORITY	_____	_____	_____	_____	_____

11.LIGHTING PROBLEMS %TOO DIM_____ %TOO BRIGHT_____
WITH ELECTRIC LIGHTS _____ _____

12.LIKE APPEARANCE:

		YES	NEUTRAL	NO
SOLAR	YES	_____	_____	_____
INFLUENCE?	NO	_____	_____	_____

13.% REPORTING DISCOMFORT

		THERMAL	AIR QUALITY	GLARE	NOISE	LIGHT
ACTIVITY:	SEDENTARY	_____	_____	_____	_____	_____
	STANDING	_____	_____	_____	_____	_____
	WALKING	_____	_____	_____	_____	_____
	ACTIVE	_____	_____	_____	_____	_____
ORIENTATION:	YES	_____	_____	_____	_____	_____
	NO	_____	_____	_____	_____	_____
SEX:	MALE	_____	_____	_____	_____	_____
	FEMALE	_____	_____	_____	_____	_____
AGE:	<12	_____	_____	_____	_____	_____
	13-17	_____	_____	_____	_____	_____
	18-30	_____	_____	_____	_____	_____
	31-45	_____	_____	_____	_____	_____
	46-55	_____	_____	_____	_____	_____
	56-65	_____	_____	_____	_____	_____
	>65	_____	_____	_____	_____	_____

14.RESPONDENTS IN BLDG MORE THAN 4 TIMES IN PAST 3 MONTHS: TOTAL #_____

15.THERMAL COMFORT

		%TOO COOL	%TOO WARM
SEASON	FALL	_____	_____
	WINTER	_____	_____
	SPRING	_____	_____
	SUMMER	_____	_____
TIME OF DAY:	MORNING	_____	_____
	AFTNOON	_____	_____
	EVENING	_____	_____

16.% WHO BELIEVE THEY CAN CONTROL COMFORT_____ IS THIS WHAT THE DESIGNER INTENDED?_____ % WHO DO THESE THINGS?_____
17. COMMENTS_____
_____

APPENDIX V: REFERENCES

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