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THE "CAL-BECA" PROJECT
PART 1: NEW CALIFORNIA
NONRESIDENTIAL BUILDINGS

B.L. Gardiner

April 1985

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THE "CAL-BECA" PROJECT
PART 1: NEW CALIFORNIA NONRESIDENTIAL BUILDINGS*

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ABSTRACT

We compiled and analyzed energy consumption data for 26 new California commercial buildings designed to be energy-efficient. Data on building characteristics and design strategies were collected for 29 additional buildings for which energy data were not available. Analysis of these data is part of the "Cal-BECA" (California Buildings Energy-Use Compilation and Analysis) project to increase the measured data on energy savings from conservation measures in California buildings. The buildings, mostly large offices, are operating at a wide range of energy intensities, between 31 and 127 site kBtu/ft^2-year (86 to 388 kBtu/ft^2-year, in resource units). Almost half the sample are operating at levels between 60 and 80 site kBtu/ft^2-year. Daylighting and shading strategies are the most common energy-saving design features in this sample. We present the results of the data base project and discuss limitations of the data, which restrict evaluations of energy performance and prevent correlation of specific design strategies with energy performance.

KEYWORDS: Energy Conservation, Commercial Building, Office Building, Monitoring, Energy Efficiency.

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1. INTRODUCTION AND BACKGROUND

Many new commercial* buildings are designed and built to be energy-efficient. Measured data on the energy performance and cost-effectiveness of these buildings are needed to complement simulation data and engineering calculations on the effectiveness of energy conservation strategies in nonresidential buildings. This paper presents the results of an effort to compile and analyze measured energy consumption data for new commercial buildings in California.

This work was done as part of the "Cal-BECA" (California Buildings Energy-Use Compilation and Analysis) data base project originally sponsored by the Universitywide Energy Research Group in 1983, and co-funded by the California Energy Commission in 1984. The project was carried out in collaboration with the Lawrence Berkeley Laboratory (LBL), which maintains national "BECA" data bases on building energy performance, for all building types, under U.S. Department of Energy funding.

California has been a leader in encouraging implementation of energy-efficiency measures in buildings. In 1984 the California Energy Commission revised the Title 24 nonresidential energy-efficiency standards for new office buildings. The Commission is in the process of revising the standards for other nonresidential building types. In order to help resolve technical and policy issues associated with the implementation of these standards, there is a need for <u>measured data</u> on the performance of <u>occupied</u> buildings designed to be energy-efficient. Additionally, other government and utility programs use loans, rebates, and design assistance to encourage implementation of energy-efficiency measures in commercial buildings. Evaluation of the savings associated with these programs should incorporate metered consumption data.

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*We use the terms "commercial" and "nonresidential" interchangeably in this report to refer to all buildings, government- and privately-owned, used for purposes other than residences or industrial activities.

Few California buildings were included in the early 1984 analysis of the national BECA data base of energy-efficient commercial buildings; six of eighty-three data points were California buildings (Wall, 1984). Part of the "Cal-BECA" project was this effort to collect and analyze data for a wider sample of new energy-efficient nonresidential buildings in California.

2. METHODOLOGY

2.1 Sources of Data

We sought data on buildings for which energy-efficiency was a major design objective. Since all California buildings built to the Title 24 nonresidential standards incorporate at least some energy-efficiency features, the distinction between "conventional" buildings and those designed to be "energy-efficient" is somewhat ambiguous. We first pursued leads of buildings that incorporated "state-of-the-art" energy conservation design features in at least one area (e.g. daylighting, HVAC systems, energy management controls). Some buildings not at the forefront of efficient design were included, if energy-efficiency was a consideration in building design and operation.

Award-winning buildings from competitions sponsored by ASHRAE (American Society of Heating and Air-conditioning Engineers) and Owens-Corning Fiberglass were a major focus of the first national compilation of energy-efficient buildings (Wall, 1984). Three California winners are included in this data base. Another primary source of data for the national compilation was new Federal GSA buildings which were built to energy performance guidelines. Two of these GSA buildings are in California.

We pursued a variety of sources to collect additional leads of California buildings appropriate for inclusion in the "Cal-BECA" data base. We identified over 100 buildings leads; see Appendix B for detail on the status of data collection. Primary sources for building leads were articles from architecture and building design journals, and contacts in the building profession. In an effort to generate additional leads from architecture and engineering firms in California, a letter was sent from

the CEC, explaining the project and requesting data leads. Also, a small article in the September/October 1984 issue of Architecture California explained the project and solicited leads. Only a half-dozen responses to the letter and article were received; most were for buildings designed recently and not yet fully occupied.

2.2 Data Collection

We collect metered energy consumption data plus building and occupancy characteristics. Data sought for each building include:

- o Building Description (type; size; location; completion date)
- o Energy-Saving Features (building envelope; HVAC system and controls; lighting and daylighting)
- o Operating and Occupancy Conditions (number of occupants; occupancy schedules; process loads; thermostat settings)
- o Energy Use (electricity, fuel, and peak demand for at least one full year of occupancy; monthly and end-use data if available)
- o Economics (construction cost; net cost of energy-saving features, if available)

Many of the buildings identified as appropriate for this data base have not been occupied for a year. For these buildings we collected data on the building characteristics, design features, and predicted energy consumption (if available). Energy and occupancy data for these buildings will be compiled for future updates of this study.

2.3 Analysis of Data

The collected data are stored in the LBL "BECA-CN" data base. We use the DATATRIEVE data base management system for storage and manipulation of the data.

At a minimum, we analyze annual whole-building data for each building. We calculate energy intensities (kBtu/ft^2-year, using gross floor area) in site and resource units for the most recent year of occupied data. There are limitations with using energy intensity as an indicator of building performance; we discuss the problems with energy intensity

comparisons. We examine the trends for buildings that have more than one year of energy data available. For buildings with utility billing records, the utility data, including consumption, peak electrical demand, and costs, are stored by billing period.

Economic analyses are hampered by lack of cost data. Ideally, we would assess the cost-effectiveness of the energy-efficiency design features by comparing the incremental cost of these features with savings in energy costs. Since these cost data are not generally available, we look for correlations among the total building construction costs, energy intensities, and annual energy costs.

For additional discussion on the framework of analysis of measured data on new energy-efficient buildings, see "A Summary Report of BECA-CN: Buildings Energy-Use Compilation and Analysis of Energy- Efficient New Commercial Buildings" (Wall et al., 1984).

3. RESULTS AND DISCUSSION

The data base contains twenty-six buildings with actual energy consumption data. Twenty-nine additional buildings have been stored in the data base with descriptive data only. Actual energy consumption data are not included on these buildings for one of several reasons: (1) the building has not been fully occupied for one year, (2) the building owners do not wish to release the energy data, (3) energy data have been requested but not yet received, (4) the building uses energy from a central source that is not separately metered (e.g. steam or chilled water from a central plant serving other buildings). Predicted energy consumption, based on simulations, is available for fourteen of these twenty-nine buildings. Below, we summarize results for the buildings with energy consumption data. More detailed results are included in data tables in Appendix A.

3.1 General Building Characteristics

The buildings with measured energy data are mostly large offices. Offices were emphasized in the data collection because of CEC interest in the performance of buildings designed to meet or exceed the 1985 Office standards. Some general characteristics of this data set are summarized below.

- **Type**: Of the twenty-six buildings with energy data, 22 are office type buildings.

- **Size**: The buildings in this sample are large; more than 60 percent are larger than 100,000 ft^2, and only 15 percent are less than 10,000 ft^2.

- **Type of Fuel**: Four of the buildings are all-electric. One building uses steam and chilled water. The remaining use natural gas.

- **Tenancy**: There are twelve public and fourteen private buildings. It is generally easier to collect energy data for public buildings, since private building owners are often concerned about release of any type of cost data, including utility billing records. The reluctance of building owners to release data may decrease as greater numbers of buildings are incorporated into the BECA data bases.

- **Location**: The buildings are located throughout the state, with the majority located in the San Francisco Bay Area or Southern California.

- **Features**: Common energy-saving design features include daylighting and shading strategies, energy-management systems, and thermal storage.

3.2 Energy Performance

The median site* energy intensity for the offices in the sample is 62 kBtu/ft^2-year and the average is 67. In resource energy, the median usage is 184 kBtu/ft^2-year. The median electricity intensity is 13 kWh/ft^2-year. Aggregate statistics for the data base are limited and should be used carefully since the sample size of twenty-six buildings (22 offices) is relatively small.

Figure 1 shows the range of site energy intensities for the office type buildings. Figure 2 shows the distributions of energy intensities, in resource energy, for the California offices and all the offices in the national data base. The California buildings cover the same range as the national sample but the distribution is skewed slightly to the higher ranges; California buildings in the sample use more energy on average than the national sample. The California offices peak in the range of 180 to 200 kBtu/ft^2-year; the national sample peak is in the range of 140 to 160 kBtu/ft^2-year. Some stock and building code intensity values are noted on the figures. See "Baseline Comparisons" below for discussion of these background values.

Electricity usage accounts for most of the energy consumption of the majority of the buildings in the data set. For more than half of the buildings, over 75 percent of the site energy usage is electricity, and for one-third of the buildings, electricity accounts for over 90 percent of site usage. Natural gas or steam usage does account for a significant portion of the energy usage in a few cases, however. For three of the buildings, less than half the site usage is electricity. High fuel use is interesting to note because strategies to conserve heating energy in large commercial buildings are often given low priority; Common wisdom holds that cooling and lighting loads always dominate. See Figure 3 for a breakdown of fuel and electricity intensities, using CEC resource units.

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*Site energy units are calculated using 3413 Btu/kWh. We use 11,500 Btu/kWh for resource units to account for typical power plant efficiency of less than 33 percent and transmission losses of approximately 10 percent; the CEC uses 10,239 Btu/kWh. Unless otherwise noted, all resource units for this paper have been calculated using 11,500 Btu/kWh.

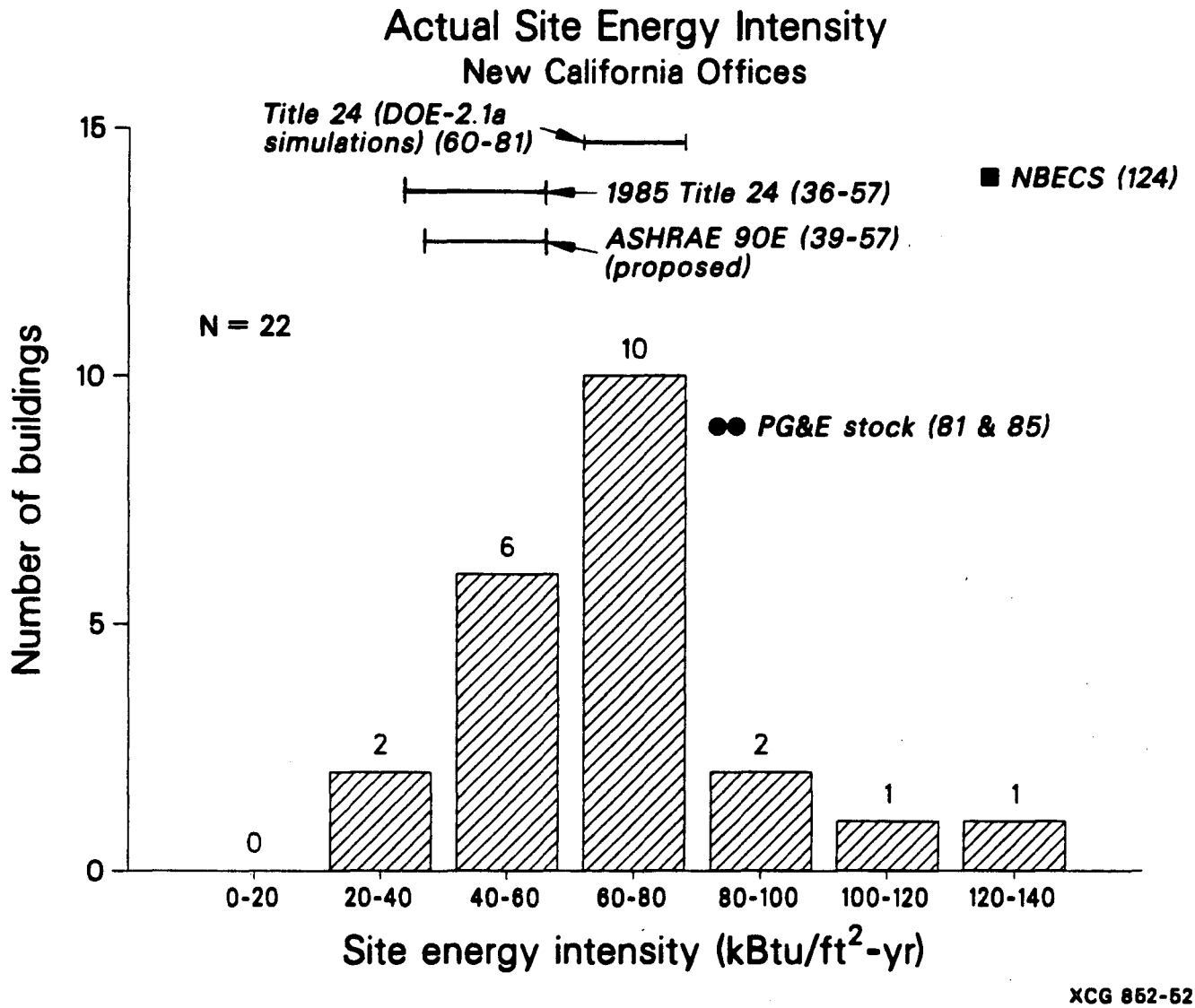

Figure 1. Site intensity of new California offices. Based on one year of energy consumption normalized by gross square footage (excluding parking). The median is 62 kBtu/ft^2-year. Almost one-half of the sample are in the range of 60-80 kBtu/ft^2-year and over 80 % use less than 80 kBtu/ft^2-yr. See text for discussion of benchmarks.

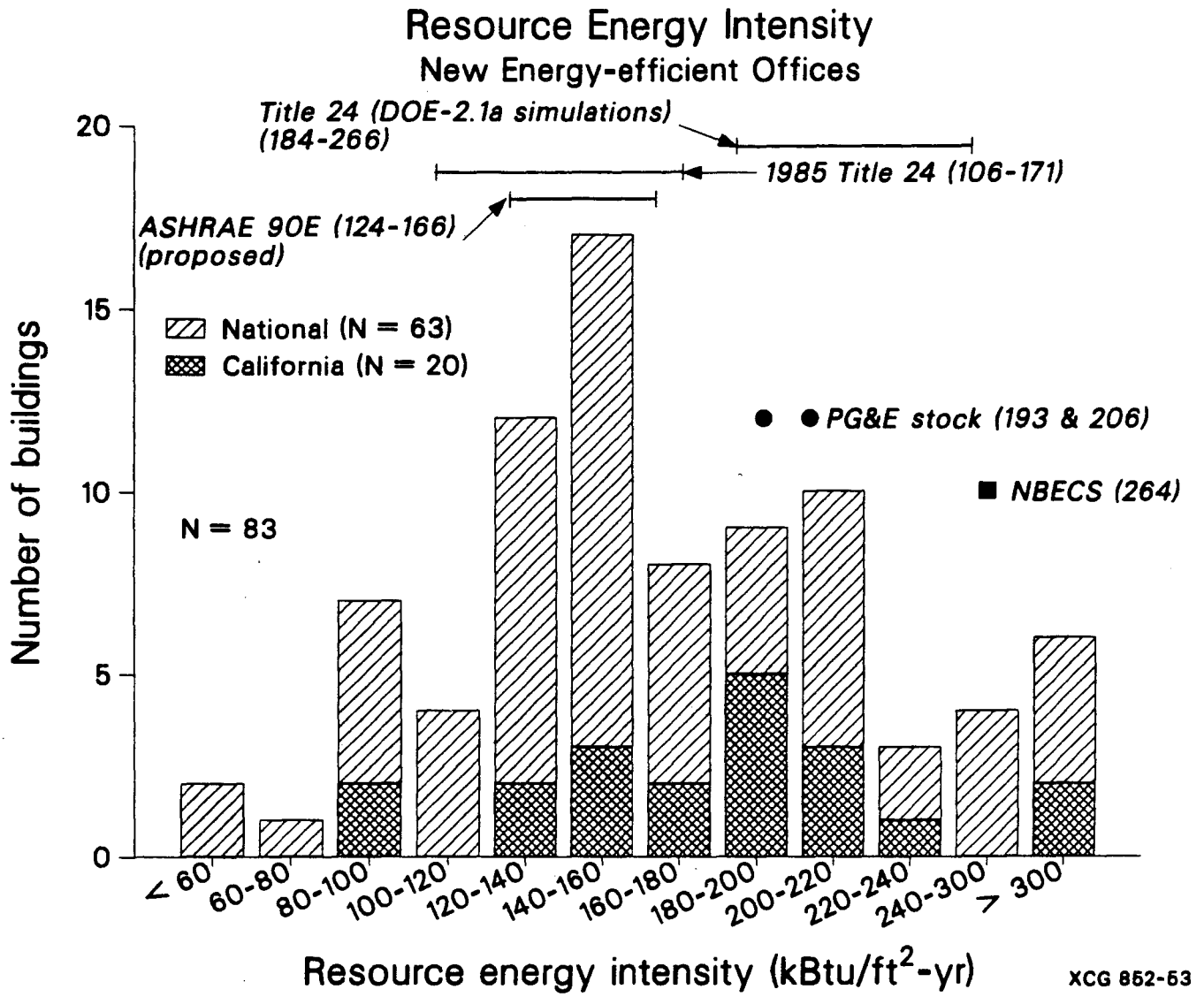

Figure 2. Resource energy intensity of California offices compared to offices in the national BECA-CN data base. Title 24 ranges are based on DOE 2.1a simulations and have been adjusted to reflect resource energy intensity units of 11,500 Btu/kWh. The published range of 1978 Title 24 budget levels is 124 to 165 kBtu/ft^2-year (using 10,239 Btu/kWh). See text for further explanation of benchmarks.

3.3 Baseline Comparisons

A major objective in collecting and analyzing energy consumption data for new commercial buildings is to compare the energy performance of buildings containing energy-efficiency features with:

- each other
- the stock of "conventional" buildings
- code requirements
- simulated or predicted performance values.

As discussed further below, data limitations, including insufficient detail and lack of acceptable normalization procedures, make these comparisons difficult. We have included several stock and code values on Figures 1 and 2 as general benchmarks.

Stock. We show two indicators of the energy consumption of existing office stock. The Nonresidential Building Energy Consumption Survey (NBECS) of 1979 building stock found the average consumption for offices to be 124 site kBtu/ft^2-year (264 resource kBtu/ft^2-year) (EIA, 1983). The buildings in our sample are mostly below this "existing stock" value. The PG&E stock values are from commercial audit data for large and small offices (Schultz, 1984). Values from the PG&E mail survey are slightly higher for both large and small offices. The CEC and PG&E are currently working on new analyses of commercial building energy intensities for the PG&E service territory. Results of the current work will include some vintaged energy usage figures, i.e. energy consumption values for building stock disaggregated by construction date. These will permit comparison of the energy performance of the Cal-BECA buildings with new PG&E commercial building stock.

The Department of Housing and Community Development, under contract to the CEC, has developed a data base on building characteristics of residential and nonresidential buildings constructed to the Title 24 standards. These buildings would be a good source of baseline for new California buildings. Unfortunately, energy data are not compiled for these buildings.

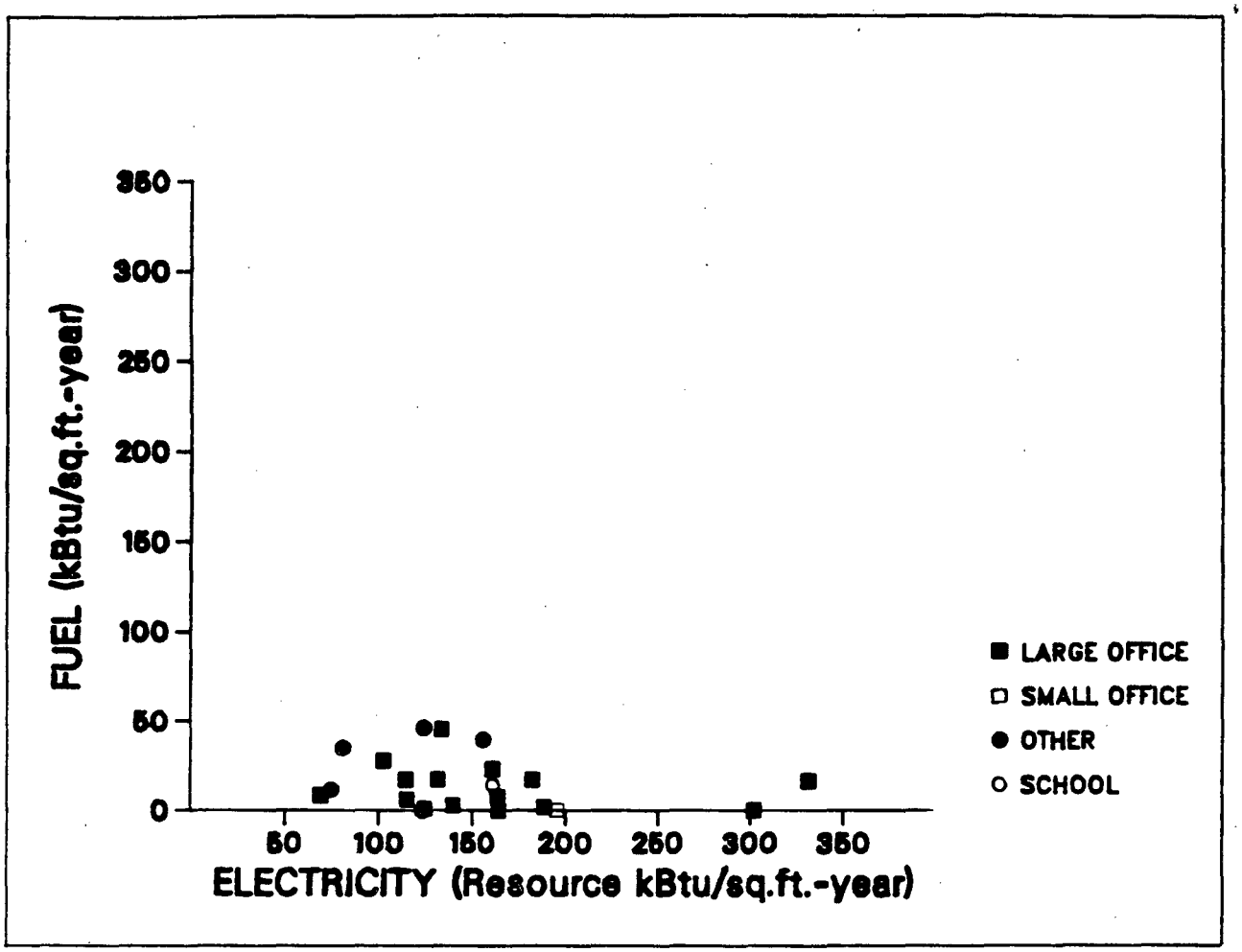

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Figure 3. Electricity and fuel use. While electricity accounts for the dominant portion of the energy consumption in most of the buildings, fuel usage (natural gas or steam) is significant for several of the buildings. Seven of the buildings have fuel intensities of over 20 kBtu/ft^2-year. Electricity is in CEC resource units (10,239 Btu/kWh).

Codes. Three code benchmarks are shown on the Figures: proposed ASHRAE 90-E standards, existing and 1985 Title 24 standards.

Ranges of budget levels for 1985 Title 24 standards are based on DOE 2.1a computer runs of a high-rise and low-rise office. Similar runs for existing Title 24 standards result in numbers significantly above the published budget levels. The published budget levels of the current office standards range from 124 to 165 kBtu/ft^2-year (CEC resource units), in the same range as the budget levels for the 1985 standards. Instead of putting the published budget levels on the Figures, we show ranges from the DOE 2.1a runs (adjusted to 11,500 Btu/kWh for resource units). These results of the computer runs provide a consistent representation of the existing and new standards, and are more appropriate numbers for comparison to real buildings (CEC, 1984).

The ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) numbers are based on simulations of buildings designed according to the proposed ASHRAE 90-E standards. Energy use was determined through DOE-2 simulations of prototypes; these ranges are an approximation of how buildings would perform under the standard (Battelle PNL, 1983).

Note that both the Title 24 and ASHRAE numbers are intensities normalized by conditioned floor area (our building data is normalized by gross floor area) and do not include all loads on the metered consumption (e.g. exterior lighting). In addition they are based on standard design and operating conditions.

Predicted versus Actual Energy Use. Comparing predicted and actual consumption and understanding discrepancies is an objective in analysis of the BECA-CN database. In California there are at least two types of simulations performed to "predict" energy consumption of new buildings: (1) simulations to document compliance with the Title 24 budgets; and (2) simulations to predict actual consumption. Many buildings meet the "prescriptive" requirements for Title 24 compliance and no computer simulations are made to predict performance. Even when simulations are made, they are often done to test the relative performance of different strategies, not to predict actual performance. Process loads are

generally excluded from simulations. Therefore, discrepancies between "predicted" and actual consumption are to be expected, especially since buildings are rarely operated according to rather rigid design conditions.

There are large discrepancies between predicted and actual energy consumption for a few of the California buildings; actual energy use is significantly greater than predicted. We suspect that this is due to a combination of factors:

(1) higher than anticipated occupancy hours;

(2) process loads;

(3) failure to correctly implement and use the energy-efficiency design features.

For example, the Department of Justice building, located in Sacramento, is occupied longer hours than anticipated, which has limited the effectiveness of one design feature. A night flushing system to cool down the structural thermal mass has not been used because it causes turbulence and noise unacceptable to nighttime occupants in the building's corridors. In another building we visited, the lighting controls were not operational; all the lights were on all day in spite of ample daylighting in many areas of the building.

Limitations in the data and definitional problems mandate cautious use of any "baseline" comparisons. For example, the NBECS survey includes indoor parking in the square footage values that they use to calculate intensities, while we do not. Factors that affect energy intensity comparisons are discussed further below.

3.4 Factors Affecting Energy Intensity Comparisons

Energy intensity can be a misleading measure for comparisons of energy performance among buildings. Key factors influencing the energy intensity include:

- o floor area

- o exterior lighting
- o occupancy
- o temperature settings
- o process loads
- o climate/weather

The floor area problem arises because there is no universally-accepted way of defining and reporting building space. There are many floor area values used for commercial buildings. These include "net leasable area", "fully conditioned area", "heated only", etc. We try to collect information on the gross (total) floor area of each building and the portions that are fully or partially conditioned. We also record parking areas that are ventilated and/or lit. We have used gross square footage values (excluding parking areas) to calculate energy intensities. Some of the baseline values use other floor area definitions, thus limiting the validity of comparing energy intensities. We have used gross square footage primarily because it is most uniformly available. Also, there are many loads associated with nonconditioned space, including lighting. Using gross floor area does not, however, account for the energy used for exterior lighting and parking garage ventilation, which is usually included in the metered consumption but has no direct relationship to the gross floor area of the building.

Variations in occupancy schedules and operating conditions are two other factors that are not accounted for in energy intensity comparisons. For example, the GSA buildings do not contain as many design features as most other buildings in the sample, yet their energy intensities are among the lowest. These buildings are operated during normal office hours, and thermostat settings are 65 degrees for heating and 78-80 degrees for cooling. This may partially explain their low energy usage. Many other buildings in the sample have longer occupancy hours or have thermostats set for a much narrower range. The building with the highest energy intensity, for example, is kept at a constant 72 degrees and is operated for 16 hours each day.

Process loads, including computer loads as the most notable example in large office buildings, are difficult to account for in evaluating energy performance in commercial buildings. Separate cooling systems for large computer systems, and heat recovery from computer rooms are complicating factors, even in cases where there are estimates of the process load intensities.

Weather variation is an additional complicating factor. There is no widely-accepted method for weather-normalizing commercial building energy performance. We have divided the buildings into 5 climate zone groups (based on the CEC climate zones). Currently, there are too few buildings in the data base to look for climate-based trends. Figure 4 shows the site energy intensities of the offices by size and climate zone.

3.5 Energy Performance Over Time

Monthly energy data for more than one year can provide additional insights into the energy performance of a building and the impact of changing operating and weather conditions. Many building operators report that there is an initial "shakedown" period in new commercial buildings. During this period, the bugs in operation of the systems must be worked out and fine tuning done to insure optimal building performance.

We have plotted the monthly energy consumption of buildings that have more than one year of occupied energy data available. Figures 5 and 6 show two examples. For both buildings, the monthly trends document a clear seasonal response for both heating and cooling energy. In the building shown in Figure 5, additional design features were implemented after the building's completion. Energy use has decreased steadily, although gradually, during the first years of operation. Energy use has increased in the building shown in Figure 6. The building operator suggests that increasing computer loads are probably responsible.

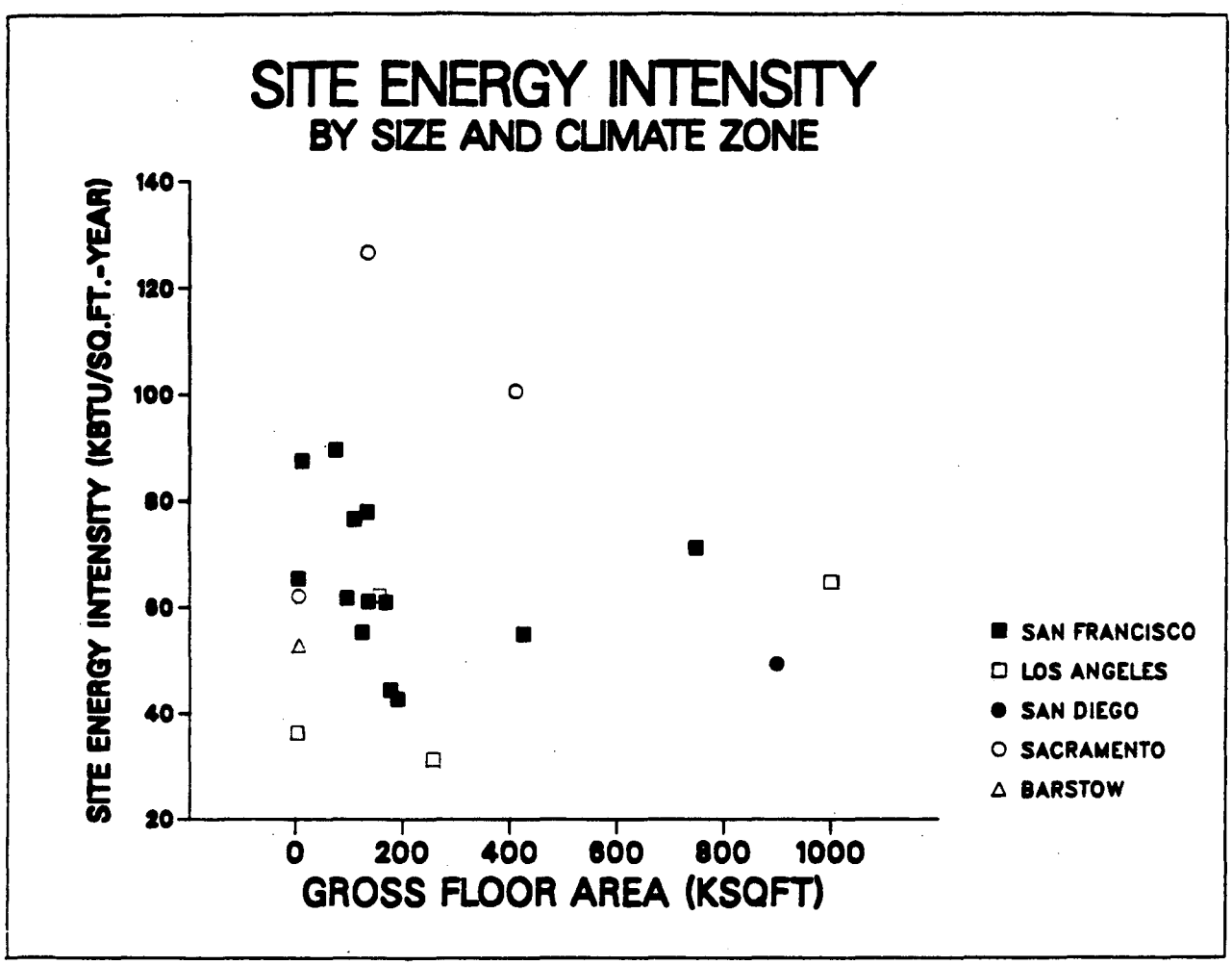

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Figure 4. Site energy intensity by size and climate region for the 22 new office-type buildings. There does not seem to be any correlation between size and energy intensity. We divided the buildings into 5 CEC climate zone groups: 1-5; 6,8,9,10; 11-13; 14,15. The sample size is too small to draw conclusions about the impacts of climate. For this sample, the Sacramento area buildings are among the high users and the Los Angeles area buildings mainly among the lowest.

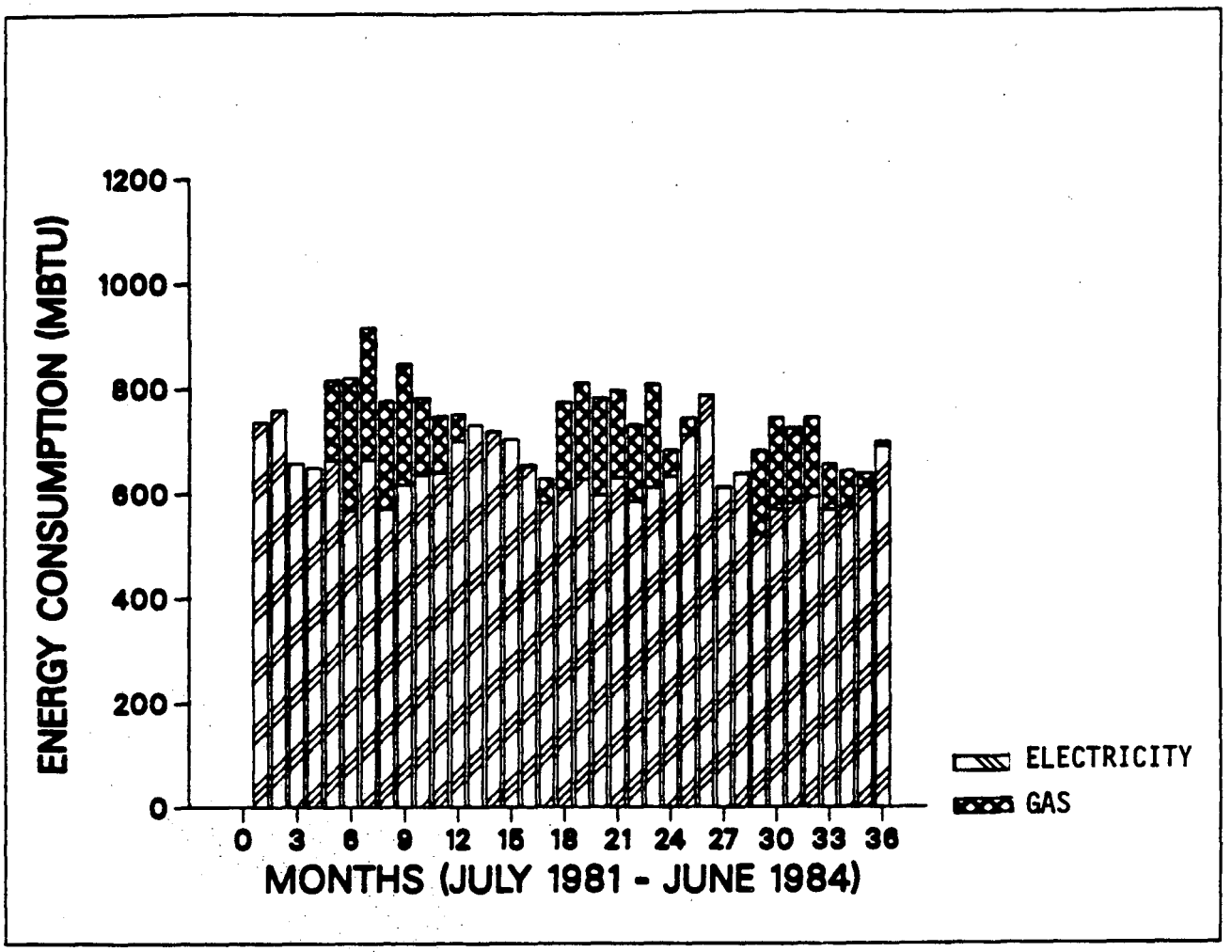

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Figure 5. Monthly energy profile for a Southern California Civic Center office building. The main energy conservation features in this 136,000 square foot building are shading and siting strategies. An energy management system and personnel sensors for lighting were installed at the end of 1983. Both electricity and gas totals have decreased slightly with each year of operation. The seasonal impacts on gas and electric usage are clear.

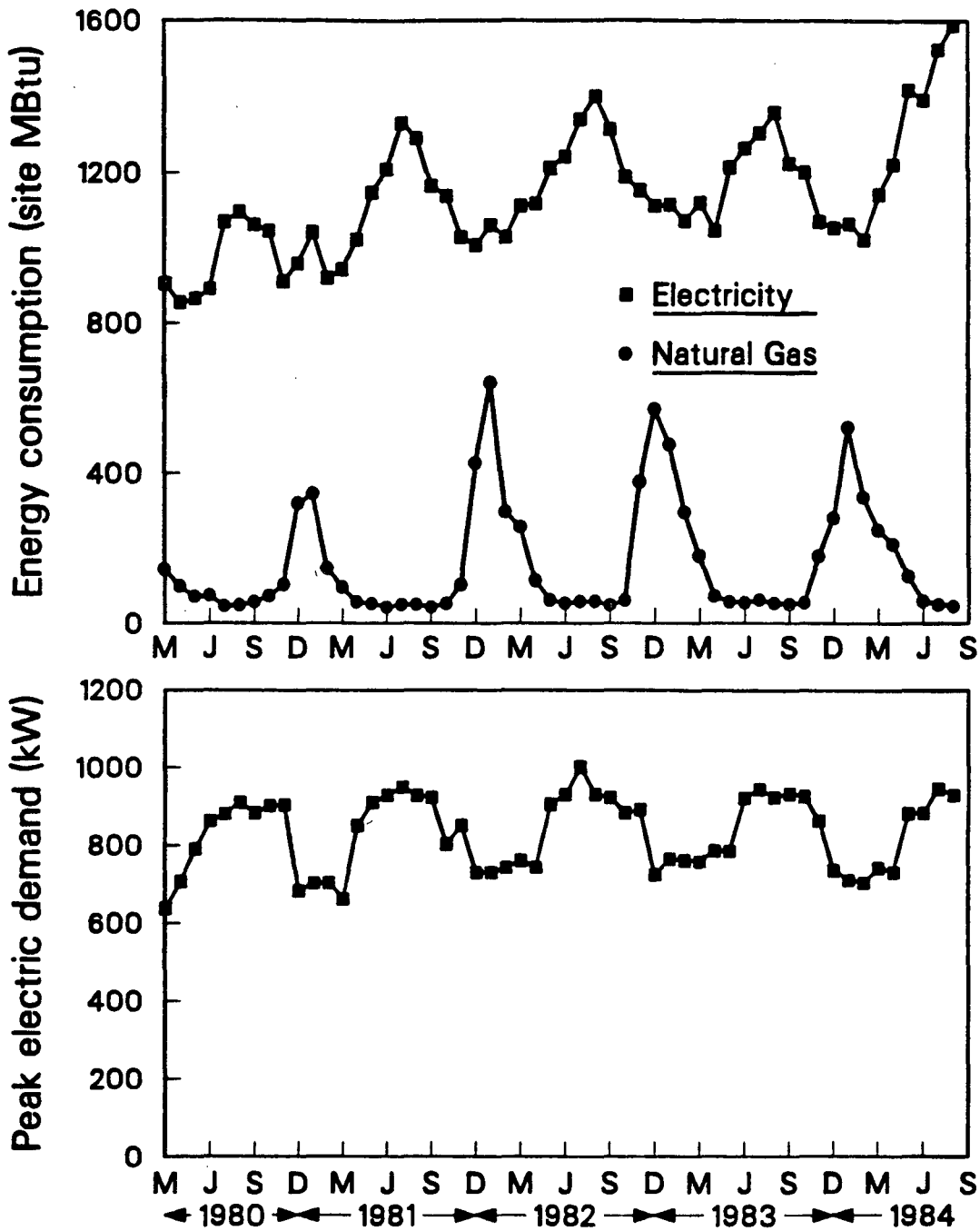

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Figure 6. Time trend energy data for a 135,000 square foot award-winning office building. The building, completed in 1979, is operating at a high, and apparently increasing, consumption level. Occupancy hours and computer loads are cited as possible explanations. Again, the seasonal impacts on gas, electricity, and electric peak are obvious.

We anticipate that tracking more of the buildings, as multi-year data become available, will show a variety of trends in energy consumption. For example, since it appears that energy-saving design features have not been completely implemented in several buildings in our sample, we expect consumption in some of the higher energy-using buildings to drop. Of course, addition of internal loads, such as computer equipment, may offset any improvements.

3.6 Electricity Demand

Many utility rate structures for commercial buildings encourage reduction in peak electricity demand (kW) and shift of electricity usage (kWh) to off-peak hours. Thus, design strategies to decrease the utility costs of operating commercial buildings include thermal storage and off-peak chilling. Many of the buildings in our sample use off-peak chilling to store ice or cold water for use during the periods when the building is occupied. In these buildings, energy intensities may not be lower than in conventional buildings, but energy costs should be less if the peak is reduced and/or the energy used off-peak is billed at a lower rate.

Figure 7 shows annual peak electric demand compared to electricity intensity for 12 large office buildings. Although the building with the highest energy consumption also has the highest peak, it is interesting to note that for buildings with peaks of 4-5 w/ft^2 there is quite a range of electricity intensities (10-20 kWh/ft^2-year). Since most of the buildings are not all-electric, we also compared total energy intensity (fuel and electricity) to peak electric demand--the results were similar. We are not able to specifically attribute low-peak demand results to load-management strategies for this sample; some of the low-peak demand buildings have load-management strategies but the buildings with the highest peaks also have off-peak storage. Clearly, load management strategies are vital in large commercial buildings, and strategies to keep peak electric demand down and energy use shifted to off-peak hours are becoming increasingly prevalent. More data are needed to evaluate the results of demand-control and load-management strategies in commercial buildings.

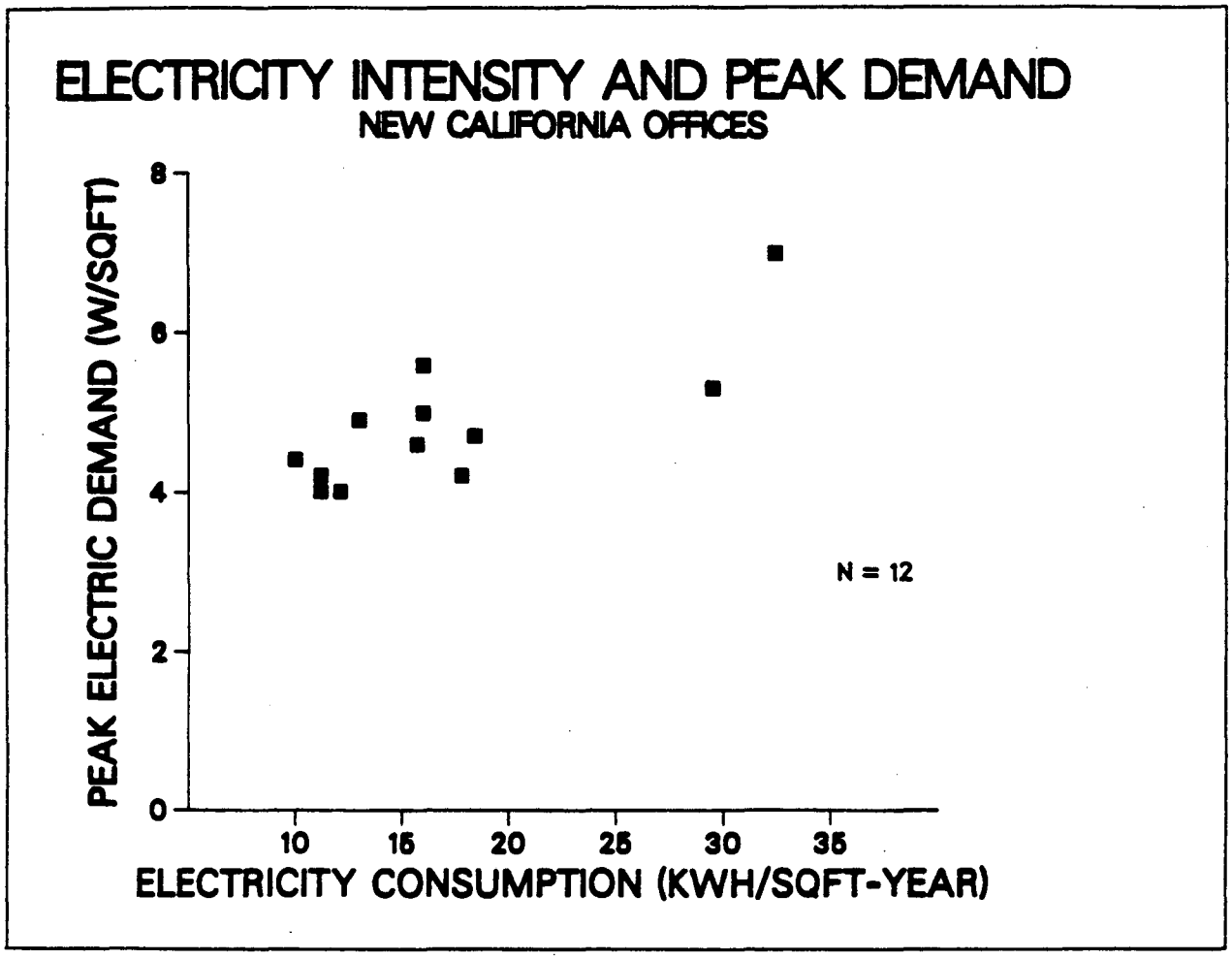

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Figure 7. Electricity intensity and peak electric demand for 12 of the offices in the sample. Note that there is a wide range of electricity intensities (10 to almost 20 kWh/ft^2-year) among buildings that have relatively similar peak demands (4-5 W/ft^2-year). Not all these buildings are all-electric; results are similar when total energy intensity is compared to peak electric demand.

3.7 Economics

We collected data on the construction costs of the buildings, and, where available, the net incremental costs of the energy-saving features. As mentioned above, the data necessary to assess the cost-effectiveness of individual design features are not available. In a very limited economic analysis, we compare the total construction cost of a building with the energy intensity and annual energy cost. We have found no correlation, either for this sample or for the national BECA-CN compilation. This suggests that low-energy buildings do not necessarily have high construction costs. Of course, construction costs vary greatly due to factors other than energy-efficient design. The high costs of some of the buildings in our sample might also be due to the fact that they are "fancy" buildings, e.g. corporate-headquarters built with expensive features.

We have also looked at whether these buildings are expensive to operate. We found little data on the operating and maintenance costs associated with the efficiency features, so we can not assess whether these buildings are more or less expensive to run than conventional buildings. We did look at the energy costs of the buildings. Figure 8 shows the annual energy costs compared to resource energy intensity. Since these buildings are in different utility service territories, and operate under varying rate schedules, their energy costs are not strictly comparable. With only one exception, they are below the BOMA average operating cost of $\$1.50/ft^2$ (BOMA, 1983).

3.8 Features

As mentioned, the data base contains many buildings that were designed with energy-efficient strategies but that do not have energy consumption data. Figure 9 shows some of the most common design features of all the buildings in the data base. Various energy-saving features have been applied to the building envelopes, lighting, and HVAC systems and controls of these buildings. We have found that some buildings are designed with features that get dropped along the way and are not included in the occupied, operating building. On the other hand, even quite new buildings are retrofit with energy conservation measures.

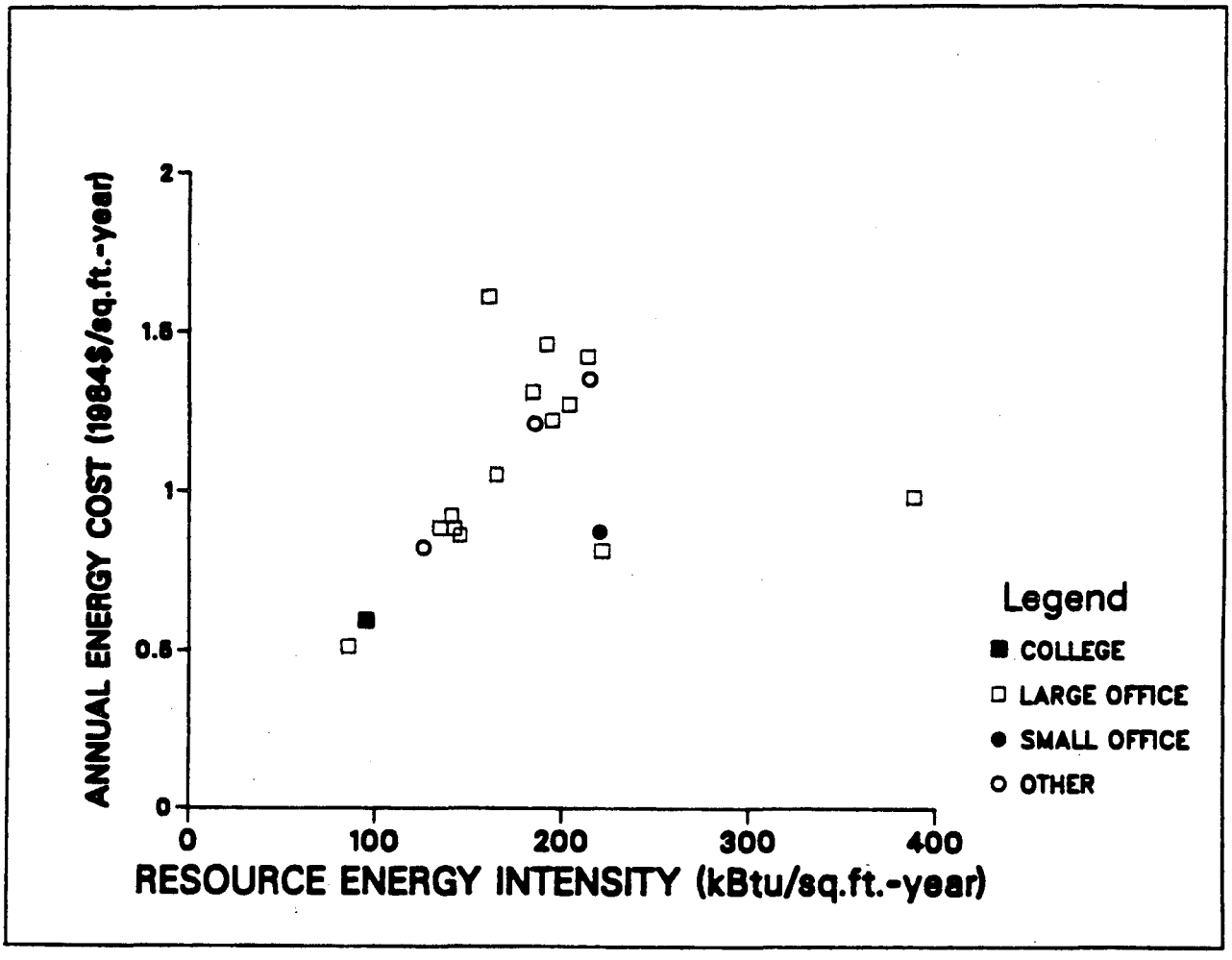

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Figure 8. Annual energy cost compared to resource energy intensity for new California buildings. The buildings are in different utility regions with varying unit costs and rate structure options. The costs are almost all below the BOMA (BOMA, 1983) average of $1.50 1983$/ft^2-year.

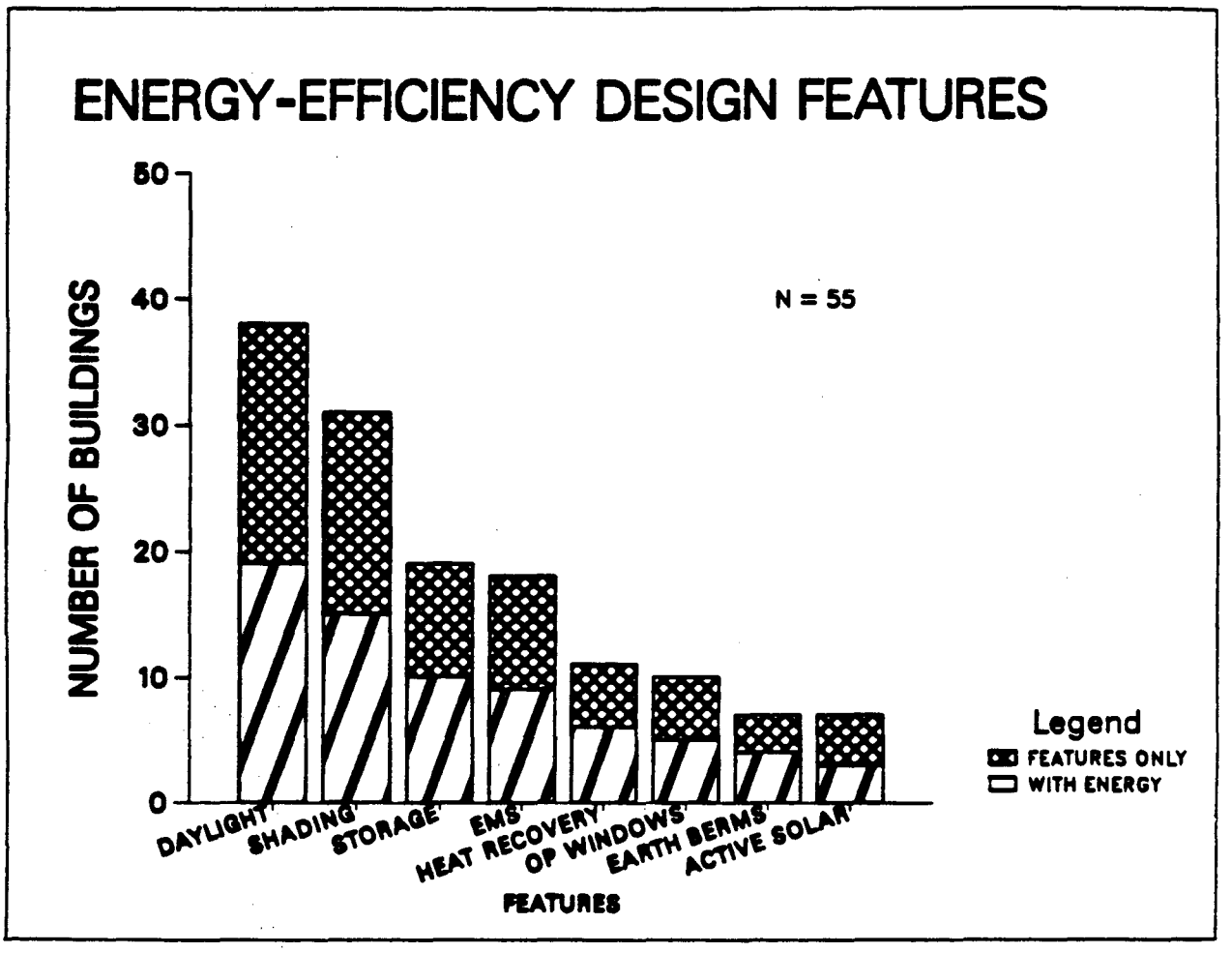

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Figure 9. Common categories of energy-saving features implemented in the new commercial buildings. These numbers are conservative because, in some cases, all the features have not been reported to us.

Site visits help clarify which features have been installed and are being used in the buildings.

4. CONCLUSIONS AND IMPLICATIONS FOR FUTURE WORK

The data presented here are initial results from studying a sample of California nonresidential buildings designed to be energy-efficient. The buildings are performing well below stock averages but, in general, not as well as expected. Many of the buildings have been touted as very low-energy-consuming buildings. Design predictions, literature quotations, and budget levels for standards all lead to the expectation that a survey of the "best" buildings would find more buildings performing below the average of this sample.

As discussed above, however, it is difficult to characterize the building energy performance of commercial buildings. Additional data are needed to develop standardized techniques to normalize energy consumption for process loads, occupancy conditions, and weather. Many of the buildings are concentrating on demand-control strategies: we also need to incorporate load-profile and time-of-use data into evaluations of commercial building energy performance.

It may be the case that occupancy, operating, and weather conditions affect the energy consumption of commercial buildings more than the presence of energy-efficiency design features. We emphasize that this does not imply that energy efficient design is not successful-- a given building may use far less energy with the incorporation of energy-efficiency design strategies--only that these factors must be explicitly accounted for in evaluating the performance of commercial buildings.

Additional data collection needed to help resolve these issues should proceed in two general directions: (1) more detailed data (including end-use data, load-profiles, and details of building occupancy and operating conditions); and (2) data on more buildings, including "conventional" new California construction built to current Title 24 standards.

Most of the data points include only whole-building metered consumption. Submetered data, even for a few buildings, will help us interpret the whole-building billing data. For example, submetering the computer loads of a few office buildings would provide ranges of electricity consumption attributable to computers. This may indicate that computer loads are not sufficiently large to explain the high usage of some new buildings--the high energy intensity is due to other factors. An end-use monitoring project underway in the Pacific Northwest may help in evaluation of California buildings. In addition, we have collected end-use data on two California buildings and hope to receive more in the next few months. We are also investigating energy management system data-logging capabilities as a low-cost alternative to expensive submetering. More site visits would enable collection of needed occupancy and operating details.

Expansion of the data base to include more buildings with whole-building metered data would also enable further analysis. With a larger sample of buildings, we could look for correlations between energy use and climate, for example. We could also begin to correlate energy performance with specific design strategies, and operating practices.

5. ACKNOWLEDGMENTS

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6. REFERENCES

Battelle Pacific Northwest Laboratory (PNL), Recommendations for Energy Conservation Standards for New Commercial Buildings, Volume III: Description of Testing Process, Report #DOE/NBB-0051/6, October, 1983.

Building Owners and Managers Association (BOMA), 1983 Experience Exchange Report, Washington, D.C., 1983.

Energy Conservation Standards for New Nonresidential Buildings, California Administrative Code, Title 24, Sections 2-5301 through 2-5343.

Energy Conservation Manual: Designing for Compliance, 1985 Office Building Energy Conservation Standards, California Energy Commission, September, 1984. Title-24 budget levels based on DOE 2.1a computer runs for high-rise and low-rise packages. Summary results of these runs for 1978 and 1985 standards were obtained from B.Maeda, CEC.

Energy Information Administration (EIA), U.S. Department of Energy, Nonresidential Buildings Energy Consumption Survey (NBECS): 1979 Consumption and Expenditures, Part 2: Steam, Fuel Oil, LPG, and All Fuels, Report DOE/EIA-0138(79)/2, December, 1983.

D. Schultz, End Use Consumption Patterns and Energy Conservation Savings In Commercial Buildings, Presented at the ACEEE 1984 Summer Study on Energy Efficiency in Buildings, Santa Cruz, CA, Aug. 14-22.

L. Wall, M. Piette and J. Harris, A Summary Report of BECA-CN: Buildings Energy-Use Compilation and Analysis of Energy-Efficient New Commercial Buildings. Presented at the ACEEE 1984 Summer Study on Energy Efficiency in Buildings, Santa Cruz, CA, Aug. 14-22. Also appearing as Lawrence Berkeley Laboratory Report No. 17882.

APPENDIX A: DATA TABLES

Data Table 1: Building Characteristics n = 26

A	B	C	D	E	F	G	H1	H2	I1	I2	J	K1	K2
BUILDING ID	LOCATION	BLDG TYPE	YEAR BLT	FLOOR AREA (K SQ FT)	NO OF STRUC	NO OF FLR	WALL U VALUE	ROOF U VALUE	NO OF PANES GLASS	PCT GLASS	INST LITE (W/SQFT)	AVG OCC (/KSQFT)	OCC HRS
136	CALIFORNIA	LOFF	1982	1000.0	2	21			1	60 %	1.6	5.3	F
24	SAN DIEGO	LOFF	1976	899.2	1								
147	SAN FRANCISCO	LOFF	1981	748.7	1	38			1	50 %			E
145	CALIFORNIA	LOFF	1982	426.0	1	3	.170	.190	2	60 %		2.3	E
74	SACRAMENTO	LOFF	1982	410.0	1	2	.070	.070	2		2.5	4.9	
23	VAN NUYS	LOFF	1975	258.2	1								
149	SAN FRANCISCO	LOFF	1980	191.0	1	19			1	50 %			
143	BURLINGAME	LOFF	1980	177.6	1	9			1			3.9	R
141	WALNUT CREEK	LOFF	1982	168.0	1	3			1		3.0		E
117	LONG BEACH	LOFF	1982	156.0	1	4	.070	.040	1	38 %	4.0		R
126	ANAHEIM	LOFF	1980	136.1	3	7	.080	.050	1			2.2	R
67	SACRAMENTO	LOFF	1979	135.0	1	2					2.1		F
140	SANTA CLARA	LOFF	1981	134.0	1	3						2.4	
115	SAN JOSE	LOFF	1982	125.0	1	3	.050	.060	1	38 %	1.9		
135	SANTA ROSA	LOFF	1983	110.0	1	3						2.7	F
116	SANTA ROSA	LOFF	1983	96.0	1	4	.060	.040	1	37 %	1.8		
148	PLEASANTON	LOFF	1983	75.0	1	3					2.3		
128	PALO ALTO	SOFF	1980	4.6	1	1							
144	STANFORD	COLL	1977	152.0		7		.100	1	50 %		1.6	
61	SANTA ANA	ELEM	1974	46.6								17.2	R
133	PALM DESERT	BANK	1982	6.5	1								
127	CALIFORNIA	OTHR	1982	66.0	1	1			2				F
64	MTN VIEW	OTHR	1979	43.0	1	2	.050	.033	2		2.6		F
132	SANTA ROSA	OTHR	1980	12.7	1	1	.050	.050	2		2.3		
125	DAVIS	OTHR	1982	5.2	1	1	.090	.050				4.0	E
137	LOS ANGELES	CLIN	1983	4.8	1	1	.091	.033	1			3.1	E

Data Table 2: Energy Data n = 26

A	L1	L2	M	N1	N2	O	P	Q	R
	< ——ANNUAL ENERGY USE PER SQUARE FOOT—— >							ANNUAL	
BUILDING ID	ELEC (KWH)	FUEL (KBTU)	SITE (KBTU)	RESOURCE (KBTU)	CEC RESOURCE (KBTU)	PREDIC SITE (KBTU)	PEAK (WATTS/ SQFT)	ENERGY COST ($/SQFT)	CONSTRUCTION COST ($/SQFT)
136	18.4	1.6	64.5	213.6	190.4		4.7	1.42	
24	13.7	2.6	49.2	160.7	142.5			1.61	
147			71.0						
145	16.0	0.0	54.7	184.2	164.0		5.0	1.31	
74	29.5	0.0	100.6	339.0	301.9	38.0	5.3		69
23	6.8	8.2	31.3	86.1	77.6			0.51	
149	12.1	1.1	42.5	140.6	125.3		4.0	0.92	80
143	11.2	5.9	44.2	134.8	120.7		4.0	0.88	
141	12.8	17.1	60.8	164.5	148.3			1.05	
117	16.0	7.5	62.1	191.5	171.3	53.0	5.6	1.46	
126	16.0	6.3	60.9	190.5	170.3	45.0			117
67	32.4	16.1	126.6	388.5	347.7	40.0	7.0	0.98	107
140	17.8	16.9	77.7	221.7	199.3		4.2	0.81	80
115	11.2	17.0	55.1	145.2	131.2	58.0	4.2	0.86	
135	15.7	22.8	76.4	203.6	183.7	35.0	4.6	1.27	
116	10.0	27.5	61.6	142.4	129.8	42.0	4.4	0.88	
148	13.0	45.1	89.4	194.4	178.0		4.9	1.22	
128	19.1	0.0	65.2	219.9	195.7			0.87	
144	10.5	72.4	108.1	212.4	179.5				98
61	15.7	14.0	67.7	194.9	175.1				63
133			52.7						
127	12.0	0.0	41.0	138.1	122.9	61.0			131
64	15.2	39.5	91.4	214.4	195.3			1.35	103
132	12.1	46.1	87.3	184.9	169.7			1.21	
125	7.9	35.0	61.9	125.7	115.7			0.82	92
137	7.3	11.5	36.3	95.3	86.1		6.7	0.59	68

Data Table 3: Design Features n = 26

A	S	T	U	V1	V2	W
BUILDING ID	DAYLIGHT CODES	SPECIAL EQUIPMENT	SPECIAL CONTROLS	HEATING DESCRIP	COOLING DESCRIP	COMMENTS
136		ST OT	EMS	BO		TWO BUILDINGS
24		SH	ESM			GSA; NOT VERY "ENERGY-EFFICIENT" DESIGN
147	AT	EZ	EMS OA			ENERGY DATA NOT YET ON FILE; PART RETAIL
145	SKY AT	FS HR	EMS	HR	CH	SOME SUBMETERING; BUILDING SOLD
74	CL AT	ST HR EZ	EMS OA	HR	C	PRED. ENRG EXCLDS PROCS.
23						GSA; NOT VERY "ENERGY-EFFICIENT" DESIGN
149		OP	OA	HP		
143		EZ	EMS	BO	CH	EMS USED TO BILL TENANTS AFTER-HOUR-USE
141	SKY	EZ	EMS			
117	AT	SH EZ HR				
126	SKY	TM FS HL	EMS		RC	EMS, LIGHTING RETROFITS 1983
67		ST ED HR EB SH	HR	BO	EC	HEAT RECOV FROM CMPTR RM A/C
140	SKY AT	MS FS TM		BO	CH	WEDGE-SHAPED BUILDING
115	AT SKY LW	ST TM EZ SH	ECS NC			
135	AT SKY	ST HR EZ FS ED			ICED	SITE VISIT; DAYLITE CNTRLS NOT WORKING
116	AT	ST EZ SH TM	NC			
148	SKY AT	SH				AWAIT MORE DESCRIPTIVE DATA
128	SKY	ST OW	NC	SO	CH	ACTIVE SOLAR
144	SKY LW CL	MS OP	NC	OS	OS	SQUARE FOOTAGE NEEDS RECONCILIATION
61		EZ TM EB				
133	SKY CL	EB		SO	SA	METERED ENERGY DATA NOT ON FILE
127	CL	ST OW SH	NC LM			
64	CL SKY	EB SH ST	EZ	BO	RC	SOLAR COOLING PLANNED BUT NOT INSTALLED
132	SKY	ST EZ SH ED	OA TM LM		OT	
125	SKY	HR EZ	OA NS	FR		REFLECTIVE COATING ON ROOF
137	CL SKY	OW SH	TM NC	HP	HP	PSYCHIATRISTS CLINIC/OFFICE

Definitions For Data Tables

A. BUILDING IDENTIFICATION NUMBER: Building identification number, assigned arbitrarily.

B. LOCATION: City where building is located. Just the state is noted in cases where the building owner requested that the building remain anonymous.

C. BUILDING TYPE: Based on predominant use of occupied space in the building. LOFF: large office building, over 50,000 ft^2; SOFF: small office building, less than 50,000 ft^2; COLL: college or university building; SECN: secondary school, high school; ELEM: elementary school, primary; BANK: banks and loan offices; WARE: warehouse; CLIN: clinic; SHOP: shopping center; RETL: retail; OTHR: other type of building (ex: community center, Department of Motor Vehicles, post office).

D. YEAR BUILT: Year construction completed.

E. FLOOR AREA: Total gross floor area in 1000 ft^2. This includes conditioned and non-conditioned spaces, but does not include parking.

F. NUMBER OF STRUCTURES: Number of structures covered by the energy data.

G. NUMBER OF FLOORS: Number of stories.

H1. ENVELOPE U-VALUE WALL: Average opaque wall U-value (English Units).

H2. ENVELOPE U-VALUE ROOF: Average roof U-value (English Units).

I1. NUMBER OF PANES: Number of window panes for most of the glazing.

I2. PERCENT GLASS: Overall percent of wall area covered by windows.

J. INSTALLED LIGHTING LOAD (W/SQFT): Installed lighting load. Data may not be consistent among buildings. We ask for average overall for the building, but data may be for the office area only, for example. Task lighting is sometimes not included.

K1. OCCUPANTS NUMBER/K SQFT: Average number of occupants per 1000 ft^2, during normal occupied hours.

K2. OCCUPANTS HOURS: Building occupancy code; R-regular (40-50 hrs/week); E-extended (51-75 hrs/week); F-full (76-168 hrs/week).

L1. ELECTRICITY INTENSITY: Annual electrical energy consumption (kWh/ft^2-year).

L2. FUEL INTENSITY: Annual fuel (gas, oil, etc.) and other (steam, chilled water, etc.) consumption totals in $KBtu/ft^2$-year at the site.

M. SITE ENERGY INTENSITY: Annual site energy intensity ($kBtu/ft^2$-year). Electricity is multiplied by 3.413 to convert from kWh to kBtu.

N1. RESOURCE ENERGY INTENSITY: Annual energy intensity ($kBtu/ft^2$-year) in resource units. Electricity is converted from site to resource using a multiplier of 3.37 (11,500 Btu/kWh); steam is converted using a multiplier of 1.56.

N2. CEC RESOURCE INTENSITY: Annual energy intensity using CEC conversions for resource units; electricity is converted from site to resource using a multiplier of 3.0 (10,239 Btu/kWh).

O. PREDICTED SITE TOTAL: Predicted annual site energy intensity ($kBtu/ft^2$-year). Often the predictions do not include all of the building loads, or reflect actual occupancy and operating conditions. We try whenever possible to record the prediction method.

P. PEAK ELECTRICITY DEMAND: Annual peak electrical demand normalized by floor area ($watts/ft^2$)

Q. ANNUAL ENERGY COST (1984 $/SQFT): Total annual energy cost per ft^2. If the energy and cost data are for a year not ending in 1984, we have made a crude adjustment to first quarter 1984 dollars, by using

GNP deflators.

R. CONSTRUCTION COST (1984 $/SQFT): Total building construction cost per ft^2 excluding land. Costs have been adjusted to first quarter 1984 dollars using GNP deflators.

S. DAYLIGHT CODES: Types of daylighting strategies employed in the building. RF - reflectors for bouncing light into the building; LW - light wells; CL - clerestory Windows SKY - skylights for lighting (not included if just decorative); RM - roof monitors; AT - atrium for lighting (often for heat gain too); SH - light shelves;

T. SPECIAL EQUIPMENT:

- ST Storage (ice storage, water tanks, eutectic salts, etc.)
- TM Thermal Mass (trombe walls, passive solar)
- SO Active Solar
- OT Other
- EB Earth Berms
- EZ Economizer
- ED Direct Evaporative Cooling
- EI Indirect Evaporative Cooling
- HR Heat Recovery
- HL Heat Recovery Luminaires
- OP Operable Windows
- FS Fixed Shading
- MS Movable Shading
- SH General Shading

U. SPECIAL CONTROLS OR CONTROL STRATEGIES:

- EMS Energy Management Control System
- NS Night Setback
- NC Natural cooling/night ventilation
- TM Timers/clock thermostats
- OA Outside Air
- LM Load Management

V1: PRIMARY HEATING EQUIPMENT DESCRIPTION:

- RS Resistance (electric)
- HP Heat Pump
- BO Boiler
- IR Infrared (used in warehouses)
- FR Furnace
- RP Roof Top Package
- HR Heat Recovery
- NO None

V2: PRIMARY COOLING EQUIPMENT DESCRIPTION:

HP Heat Pump	SA Solar Absorption
CH Chiller	ED Direct Evaporative Cooler
CC Centrifugal Chiller	EI Indirect Evaporative Cooler
RC Reciprocating Chiller	IC Ice Storage
AC Absorption Chiller	OS Off Site Source
RP Rooftop Package	OT Other
DR Direct Expansion	

W. COMMENTS: Miscellaneous information.

APPENDIX B: STATUS OF DATA COLLECTION

New Commercial Buildings in Cal-BECA Data Base

Building Type	Location	Floor Area (gross) k sqft	Floor Area (cond.) k sqft	Year Built	Major Conservation Design Features	Energy Data
State Buildings:						
Large Office	Sacramento	410.0	365.1	1982	Waste Heat Recovery; Water Storage; Courtyards	x
Large Office	Long Beach	156.0		1982	Daylighting; Shading; Atrium	x
Large Office	San Jose	125.0		1982	Rockbed Storage; Night Cooling; Courtyards	x
Large Office	Santa Rosa	96.0		1983	Storage; Atrium; Daylighting	x
Dept. Motor Veh.	Santa Rosa	12.7	12.7	1980	Rockbed Cooling; Solar Hot Water	x
Dept. Motor Veh.	Davis	5.2	5.2	1982	Skylights; High Effic. Furnace, Lights	x
Federal Buildings:						
Large Office	San Diego	899.2		1976	Shading; Energy Management System	x
Large Office	Van Nuys	258.2	230.7	1975		x
Local Buildings:						
Civic Center	Anaheim	136.1		1980	Shading; Solar Hot Water; Thermal Mass	x
Library	California	66.0		1982	Daylighting Clerestories	x
Elementary School	Santa Ana	46.6		1974	Earth Berms; Thermal Mass	x
Police/Fire	Mountain View	43.0	43.0	1979	Insulation; Earth Berms; Daylighting	x
Private Buildings:						
Large Office	California	1000.0	959.7	1982	Chilled Water Storage	x
Large Off./Retail	San Francisco	748.7	748.7	1981	Energy Management System; Outside Air	x
Large Office	California	426.0	309.0	1982	Shading; Daylight; Energy Management	x
Large Off./Retail	San Francisco	191.0	177.4	1980	Operable Windows; Heat Pump System	x
Large Office	Burlingame	177.6		1980	Energy Management System; Energy Miser	x
Large Office	Walnut Creek	168.0		1982	Energy Management System	x
College Building	Stanford	152.0	104.2	1977	Passive Solar; Natural Ventilation Ballasts	x
Large Office	Sacramento	135.0	119.0	1979	Earth Berm; Evaporative Cooling; Storage	x
Large Office	Santa Clara	134.0		1981	Daylighting; Passive Solar Wedge Shape	x
Large Office	Santa Rosa	110.0		1983	Ice Storage; Atrium; Heat Recovery	x
Large Office	Pleasanton	75.0	72.0	1983	Daylighting	x
Bank	Palm Desert	6.5		1982	Active Solar	x
Office/Clinic	Los Angeles	4.8		1983	Daylighting; Natural Ventilation	x
Small Office	Palo Alto	4.6	4.6	1980	Active Solar; Vented Skylights	x

New Buildings in Data Base — Predicted Energy Usage Or Design Features Only

Building Type	Location	Floor Area (gross) k sqft	Floor Area (cond.) k sqft	Year Built	Major Conservation Design Features	Pred. Energy	Status of Energy Data Collection
Public Buildings:							
Large Office	Sacramento	267.0		1981	Rockbed; Night Cool; Atrium	x	Steam, Chilled Water from Cent. Plant Not Monitored
Large Office	San Jose	256.0	181.0	1983	Daylighting; Courtyard;	x	Less than 1 year occupancy
Large Office	Sacramento	237.0	183.0	1982	Active Solar; Ice Storage; Earth Berm	x	Steam, Chilled Water from Cent. Plant Not Monitored
Large Office	Sacramento	160.0		1982	Concrete Slab; Night Cooling;	x	Steam, Chilled Water from Cent. Plant Not Monitored
Large Office	Sacramento	130.0		1982	Thermal Mass; Shading;Atrium	x	Steam, Chilled Water from Cent. Plant Not Monitored
Large Office	Oakland	116.0		1984	Daylighting; Shading		Less than 1 year occupancy
City Hall	Cerritos	55.0		1978	Active Solar; Daylighting		Awaiting Data
High School	San Diego	138.0		1982	Active Solar		Awaiting Data
*Elementary School	Irvine	43.0			Daylighting; Natural Cooling	x	Not yet constructed
Elementary School	Sunnymead	71.0		1984	Skylights		Less than 1 year occupancy
Post Office	San Diego	13.8	11.7	1983	Daylighting; Passive Solar	x	Less than 1 year occupancy
Visitor Center	Lancaster	2.0	2.0	1982	Daylighting; Passive Solar	x	Wind generated electricity
Private Buildings:							
*Large Office	San Ramon	2000.0	1750.0		Ice Storage; Daylighting	x	Under Construction
Large Off./Retail	San Diego	815.0		1982	27 HVAC Systems; Computerized Daylighting Controls	x	Await Data/May not release
Large Office	Los Angeles	710.7	642.1	1982	Heat Recovery; Insulated Glass		Will not release
Large Office	El Segundo	600.0		1983	Chilled Water Storage; EMS		Less than 1 year occupancy
Large Office	Sunnyvale	586.0		1983	Daylighting; Dimming Controls	x	Have not released
Large Office	Santa Monica	488.0		1984	Daylighting; Energy Management		Less than 1 year occupancy
Large Office	Los Angeles	466.0		1982	Chilled Water Storage; EMS	x	Awaiting Data
Large /Office	Long Beach	400.0			Glazing; Undulations		Will not release
Large Office	Los Angeles	315.0			Storage; Glazing	x	Will not release
Large Office	San Francisco	100.0			Active Solar; Heliostats		Awaiting Data
Office/Retail	Oakland	45.0	41.0	1980	Overhangs; Lighting		Awaiting Data
Office/Retail	La Jolla	19.1		1980	Skylights; Lighting		Awaiting Data
Small Office	Ventura	31.6		1982	Daylighting	x	Have not released
Small Office	San Diego	23.8		1979	Glulam Fascia; Clerestories		Awaiting Data
Small Office	S.Luis Obispo	18.0		1984	Insulation; Operable Windows		Less than 1 year occupancy
Small Office	San Diego	8.5		1983	Glass Block		Awaiting Data
Science Complex	Arcata	39.3		1982	Daylighting; Passive Solar		Awaiting Data
Research	Brea	250.0	156.0	1982	Ice Storage		Awaiting Data/Expansion so no separate metering
Resource Center	Santa Barbara	4.1		1984	Passive and Active Solar; Daylighting		Less than 1 year occupancy
Restaurant	San Ramon	5.2		1983	Passive Solar		Awaiting Data

* under construction

Building Leads — Data Collection is in Progress

Building Type	Location	Floor Area (gross) k sqft	Floor Area (cond.) k sqft	Year Built	Major Conservation Design Features
Large Office	San Francisco		250.0	1983	Ice Storage; Reflective Glazing
Large Office	San Francisco	826.0			
Large Office	Novato	325.0		1982	High Efficiency Motors; Evaporative Cooler
Small Office	Menlo Park	40.0		1984	Daylighting; Energy Management System
Small Office	Irvine	12.0		1980	Atrium; Clerestories; Partially Earth Bermed
Small Office	Fresno	8.0		1981	Solarium; Fabric Roof; Partially Earth Sheltered
Office/Retail	La Jolla	19.1		1980	Daylighting
*State Office	Van Nuys				
Office Buildings	San Mateo				Energy Management Sysem
Convention Center	San Francisco				Lighting System; Mostly Underground
City Hall	Grass Valley	10.0		1984	Passive Solar;Not separately metered from existing bldg
Community Center	Chula Vista			1980	Passive Solar
Library	San Juan Capistrano	13.0		1983	Daylighting; Thermal Mass
Detention Facility	Martinez	186.0		1980	Sunscreens; Courtyards
Church	Garden Grove			1980	Daylighting; Glazing
Fire Station	Ventura				Active Solar, but not functioning correctly
Branch Banks	Sacramento,				Pictured in CEC Biennial Report
	Daly City	85.0		1981	Reflective Glazing
Postal Facility	Santa Ana				Daylighting; High Pressure Sodium Lights
Elementary School	San Francisco				Large openable windows for daylight, natural cooling
Shopping Mall	Santa Monica				First Calif. mall built to Title 24 Standards
Department Stores	San Jose	150.0		1978	Fabric Roof
Restaurant/Retail	San Diego			1979	Natural Lighting
Industrial Complex	San Diego	112.1			Passive Solar, Daylighting; Tight Envelope. One of three buildings is office (36,400 sq.ft.).
Hospital(addition)	Van Nuys				Natural Lighting; Shading

* under construction

Possible Leads

Building Type	Location	Size/Floor Area (k sqft)	Year Built	Major Conservation Design Features
Bank/Office	El Toro	10 story	1984	10 Independent Ice Banks
Bank	Santa Cruz			Skylights; Clerestories
Bank	Fremont			
Theater	San Francisco			Daylighting
Church	Fresno			
Church		110.0	1983	Ice Storage
Retail	San Francisco	136.0		Daylighting
Retail	Mountain View			Won energy-efficiency design award in Santa Clara are
Retail	Los Angeles			Natural Lighting
Grocery	Colton		1973	Heat Recovery
Restaurant	Orange County			Daylighting
Office	Larkspur			Shading
Office	San Rafael			Shading
Small Office	Harbor City	32.0	1984	Ice Storage
Office	Palo Alto			Daylighting, Shading
Large Office	Irvine	70.0		Glazing
Large Office	San Diego	85.0	1983	Ice Storage
*Large Office	Los Angeles	52 story		
Large Office	San Francisco	43 story		Extensive Energy Management System
Large Office	Culver City			
Large Office	San Diego	92.0	1982	Ice Storage
Large Office	San Diego	85.0	1984	Ice Storage
Large Office	El Segundo			CALBO Awards of Excellence winner
Office	Irvine			Solar
Office	Newport Beach			Reflective Glazing
Large Office	San Francisco	220.0	1983	Ice Storage
*Office/Condo	San Francisco	392.4		Heat Recovery
Admin./Office	Costa Mesa	10.0	1983	Eutectic Salt Storage
Hospital	Los Angeles			Variable Pitch Fans
Hospital	San Jose			
TV Studios	Oakland			Stratification of air
Hotel	Newport Beach			Atrium
Industrial	San Jose			Daylighting
Wildlife Hdqtrs	Fremont	8.4		Shading
County Gov't	San Luis Obispo			
Community Center	San Jose			
Civic Center	Grand Terrace			Daylighting
High School	Irvine	96.0		Shading
Library	Saratoga			Daylighting
Auto Supply	West Covina			Daylighting

* under construction

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