LBNL-2744E

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Summary of Information and Resources Related to Energy Use in Healthcare Facilities – Version 1.0

Brett C. Singer, Jennifer L. Coughlin, Paul A. Mathew

Environmental Energy Technologies Division

September 2009

SUMMARY OF INFORMATION AND RESOURCES RELATED TO ENERGY USE IN HEALTHCARE FACILITIES – VERSION 1

Brett C. Singer, Jennifer L. Coughlin and Paul A. Mathew
Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory

DATE: September 8, 2009

Prepared in partial fulfillment of the requirements of
California Energy Commission Contract CEC-500-99-013
California Institute for Energy and the Environment Contract C-07-03

Abstract

This document presents the results of a review of publicly available information on energy use in health care facilities. The information contained in this document and in the sources cited herein provides the background and context for efforts to reduce energy use and costs in health care. Recognizing the breadth and diversity of relevant information, the author acknowledges that the report is likely not comprehensive. It is intended only to present a broad picture of what is currently known about health care energy use.

This review was conducted as part of a "High Performance Health Care Buildings" research study funded by the California Energy Commission. The study was motivated by the recognition that health care facilities collectively account for a substantial fraction of total commercial building energy use, due in large part to the very high energy intensity of hospitals and other inpatient care facilities. The goal of the study was to develop a roadmap of research, development and deployment (RD&D) needs for the health care industry. In addition to this information review, the road map development process included interviews with industry experts and a full-day workshop at LBNL in March 2009.

This report is described as "Version 1" with the intent that it will be expanded and updated as part of an ongoing LBNL program in healthcare energy efficiency. The document is being released in this form with the hope that it can assist others in finding and accessing the resources described within.

Acknowledgments

This work was conducted under contract C-07-03 administered by the California Institute for Energy and the Environment with support from the California Energy Commission, Public Interest Energy Research program, and supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Building Technologies Program of the U.S. Department of Energy under Contract No. DE-AC02-05CH1131.

Legal Notice

Disclaimer[1]

[1] Disclaimer included verbatim as required by LBNL RPM Section 5.02.03. United State Government sponsorship refers to the management contract noted in the Acknowledgments. The specific work described in this report was funded by the California Energy Commission through a contract managed by the California Institute for Energy and the Environment, also noted in the Acknowledgments.

TABLE OF CONTENTS

List of Figures

List of Tables

1 Introduction

This document presents the results of a review of publicly available information on energy use in health care facilities. The information contained in this document and in the sources cited herein provides the background and context for efforts to reduce energy use and costs in health care. Recognizing the breadth and diversity of relevant information, the author acknowledges that the report is likely not comprehensive. It is intended only to present a broad picture of what is currently known about health care energy use.

This review was conducted as part of a "High Performance Health Care Buildings" research study funded by the California Energy Commission[2]. The study is being conducted by researchers in the Environmental Energy Technologies Division of Lawrence Berkeley National Laboratory with assistance from Mazzetti & Associates (San Francisco, CA) and input from industry experts including volunteer members of a project advisory committee. The study was motivated by the recognition that health care facilities collectively account for a substantial fraction of total commercial building energy use, due in large part to the very high energy intensity of hospitals and other inpatient care facilities. The goal of the study is to develop a roadmap of research, development and deployment needs for the health care industry. This report is the first formal product in this study and sets the stage for subsequent project tasks. In parallel to this review, LBNL has conducted interviews with a collection of individuals having specific expertise in health care facility operation and energy use. The results of these interviews are being compiled into a preliminary list of RD&D objectives. A one-day workshop is being planned to expand and priority this list. The results of the workshop will be compiled into a roadmap report that will constitute the capstone product of this study.

1.1 The Healthcare Sector

Health care is provided in facilities that range from acute care hospitals that are special in their construction and operation to medical office buildings that are similar in many ways (including energy use, as shown later in this document) to other office buildings.

An excellent overview of U.S. healthcare buildings is provided as Chapter 9 of "Who Plays and Who Decides", an overview of the U.S. commercial building sector (Reed et al., 2004). The report was funded by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy and is available on the EERE website[3]. The report describes a sector that includes over 100,000 buildings containing 3 billion square feet of floor space, or which about two-thirds is associated with inpatient facilities and one third with outpatient services. The report provides information about the large players (facility owners and operators) in both the inpatient and outpatient sub-sectors and describes the organization of each sector by the types of facilities (medical purpose) and the status of the facility operators (public or private; for profit or not for profit). The report also discusses trends in consolidation, the provision of services (e.g. a shift form inpatient to outpatient facilities) and the economics of the industry. Selected information is also provided about energy use.

The American Hospital Association (AHA) collects and compiles extensive information about the hospital industry. Much information is publicly available through the AHA website in the form of tables, charts, reports, and other media compiled into *Trendwatch* reports and an

[2] CEC contract #500-99-013, CIEE #C-07-03.
[3] www.eere.energy.gov/buildings/highperformance/commercial_analysis.html

annual *Chartbook*[4]. Data presented in the online 2008 *Chartbook* indicate that as of 2006 there were 5747 registered hospitals with 947,412 beds with expenses of roughly $610 billion. The 4927 facilities registered as community hospitals – defined as nonfederal, short-term, general and special hospitals whose facilities and services are available to the general public – comprised 86% of the U.S. total hospital population. In 2006, California had 357 community hospitals that comprised 67% of the state hospital system. A critical challenge to improving energy efficiency in the health care sector is the precarious financial status of many facilities and institutional operators of facilities[5]. This concern is reflected in chart 4.1 of the *2008 Chartbook*, which indicates that roughly 25% of facilities are operating at a negative total margin.

2 Energy Use in Healthcare Facilities

2.1 Overview of Information on Healthcare Energy Use

There are several databases of publicly available information that provide insight into energy use and opportunities for energy savings in the healthcare sector.

The most directly relevant sources provide information about measured or estimated energy use in existing facilities. This information comes from large surveys of health care facilities, as described below. Data are available on the amount of each form of energy used (electricity, natural gas, fuel oil, etc.) and energy expenditures in health care facilities. Some also include estimates of breakdown by end-use, i.e. amount of energy used for cooling, heating, ventilation, lighting, etc. The energy use estimates may be available for one or more categories of healthcare buildings (e.g. hospitals) and may be linked to building or facility location, size, age, climate zone, etc.

The second category of information includes building physical characteristics; heating, cooling and ventilation equipment; and the facility operational practices (e.g. hours of facility operation, hours of lighting operation, etc.) that involve energy use. This information is also obtained primarily from surveys.

The third grouping includes energy efficiency best-practice guides for constructing, renovating, commissioning and operating health care buildings. Included in this group are anecdotal reports of energy savings and guidance on monitoring actual energy use.

2.2 Surveys and Databases of Healthcare Facility Energy Use

In the section that follows, we provide brief overviews of databases and other sources of information relevant to energy use in the health care sector. Most of the sources provide various categories of information. For example, both the California Commercial End Use Surveys (CEUS) and the U.S. Department of Energy Commercial Building Energy Consumption Surveys (CBECS) obtain information about building and system characteristics in addition to energy use and expenditures. The American Society of Healthcare Engineering (ASHE) Energy Guidebook provides information about hospital equipment and operations, and includes some best practices suggestions. EPA's Energy Star Portfolio Manager is a facility level benchmarking tool linked to resources on best practices and case study reports of energy efficiency improvements. Presented below are descriptions of these databases and selected results.

---

[4] www.aha.org/aha/research-and-trends/index.html

[5] This issue was raised by a number of industry professionals who were interviewed to identify challenges and opportunities to improve energy efficiency in health care.

Energy use surveys collect information about the energy used on site, i.e. site energy. Proper consideration of total energy use – including the total energy required to generate and distribute electricity – should focus on the "source" energy, i.e. all primary energy (as fuel) that is needed to provide energy at the site. Energy information therefore may be provided in terms of site or source energy. While the relationship between source and site energy depends on the specific mix of technologies and fuels used to generate electricity (consider for example, the difference between coal-fired power plants and hydroelectric power), a conversion factor of about 3 (Deru and Torcellini, 2006) is appropriate to convert from site electricity to source energy for the Western U.S. electrical grid.

2.2.1 Commercial Building Energy Consumption Survey (CBECS)

2.2.1.1 Overview and Documentation

The Commercial Buildings Energy Consumption Survey (CBECS)[6] is a periodic national survey that collects information on energy consumption, expenditures and relevant building characteristics for U.S. non-residential facilities. The three most recent surveys with available information collected data in 2003, 1999, and 1995. The 2003 study includes a sample of 6,380 facilities surveyed by computer assisted personal interview. Extensive documentation on these studies is available online via the U.S. Department of Energy (DOE) Energy Information Administration (EIA)[7].

Information is collected on the total amounts, costs and types of energy used (electricity, natural gas, fuel oil, etc.) and the types of energy used for specific thermal systems (heating, cooling, domestic or service hot water). The survey includes questions about the building physical and operational characteristics (e.g. year of construction, finished floor area, number of stories, and hours of operation), energy-using equipment (heating, cooling, lighting, etc.) and an array of specific characteristics that impact energy use (e.g. windows, insulation, roofing, energy management systems, etc.). The survey collects data at the level of the individual building; estimation and attribution techniques are used to assign energy use from multi-building campuses to the hospital building. A "principal building activity" (variable name PBA8) is attributed to each sampled building and special characteristics are recorded for some types of buildings. Energy use and expenditures are resolved by fuel type and reported on an annual basis.

2.2.1.2 Healthcare Facilities Sampled

The CBECS database specifies two principal building activities or types of healthcare buildings: inpatient and outpatient. The number of registered beds is included as a special descriptor for inpatient facilities. The 2003 CBECS data files include 217 hospitals and 144 outpatient facilities (52 diagnostic medical offices, 92 clinic / outpatient facilities). Nominally, the inpatient building activity can include inpatient rehabilitation facilities; however all 217 of the inpatient facilities in the 2003 dataset are labeled as hospitals (variable PBAPLUS8 in File 02). Information about health care buildings sampled in 1999 has been compiled and posted on

[6] www.eia.doe.gov/emeu/cbecs/contents.html
[7] www.eia.doe.gov/emeu/cbecs/technical_information.html

the CBECS web site[8]. No similar compilation has been posted at the CBECS site for the 2003 data.

2.2.1.3 Primary Data

Primary survey results are available on the CBECS web site as "public use microdata"[9]. The data organized into a series of smaller data files that can be re-combined to form larger databases. Each primary data file has a corresponding layout file which provides variable names, descriptions, positions in the file, and data formats. The data file is a comma separated value file. Format codes are described in a separate text document[10].

The key data files are listed in the table below.

Table 1. CBECS "microdata" files.

File	Name
1	General Building Information and Energy End Uses
2	Building Activities, Special Measures of Size, and Multibuilding Facilities
3	Heating and Cooling Equipment and Conservation Features
4	Water Heating, Refrigeration, Office Equipment and Special Space Uses
5	End Uses of Major Energy Sources, Electricity Generation, and Purchasing of Electricity and Natural Gas
6	Minor Energy Sources and End Uses for Minor Energy Sources
7	Lighting Percents, Equipment, and Conservation Features
15	Consumption and Expenditures for Sum of Major Fuels and Electricity (Includes Imputation Flags)
16	Consumption and Expenditures for Natural Gas, Fuel Oil, and District Heat (Includes Imputation Flags)

Note: files 8-14 are imputation flags for the first 7 files.

2.2.1.4 Analysis and Results

CBECS survey data are analyzed to estimate the total site energy use and other characteristics of the entire U.S. population of non-residential buildings, resolved to various categories, including building type (principal activity). Results for each study year are presented in a series of detailed data tables for each study year[11]. In these tables, some results are "withheld" (Q) due to large variability and/or small sample size (relative standard error, RSE, of greater than 50 percent or fewer than 20 buildings sampled).

Energy use estimates – expressed as total site energy and energy intensity (energy use per square foot per year) – are presented separately for electricity, natural gas, fuel oil, and sum of all fuels, and resolved by census region (n=4), building size, year constructed, climate zone (n=5) and census division (these are the "C" group of tables).

Data from CBECS are also accessible through Lawrence Berkeley National Laboratory's (LBNL) EnergyIQ online benchmarking tool for non-residential buildings[12].

---

[8] www.eia.doe.gov/emeu/cbecs/pba99/healthcare/healthcare.html
[9] www.eia.doe.gov/emeu/cbecs/cbecs2003/public_use_2003/cbecs_pudata2003.html
[10] www.eia.doe.gov/emeu/cbecs/cbecs2003/public_use_2003/formats.txt
[11] www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html
[12] http://energyiq.lbl.gov/

CBECS estimates end-use consumption by fuel and end-use application category. Starting in 1999, this has been done using a nonlinear regression statistical modeling approach[13]. The 1995 and 1992 studies used statistically-adjusted engineering approach[14].

End-use estimates are developed for the following categories: space heating, cooling, ventilation, domestic (service) water heating, lighting, cooking, refrigeration, office equipment, computer and other. End-use breakdowns are not estimated for individual buildings in the sample. Rather, end-use estimates are resolved by several variables including principal building activity. Detailed data tables E2, E4, E7, E9, and E11 provide nationwide average site end-use intensity estimates for total energy, electricity, natural gas, fuel oil, and district heat. End-use intensities are also resolved by sector, building size, climate zone, etc; but they are not resolved by building type (e.g. for healthcare) within each of these breakouts. Estimates are available for all healthcare, inpatient and outpatient buildings on a nationwide level. These results are presented in a later section.

2.2.2 California Commercial End-Use Survey (CEUS)

2.2.2.1 Overview and Documentation

The 2002 CEUS included survey data collection and extensive analysis to investigate commercial building energy use in California. The survey was funded by the California Energy Commission and conducted by a team lead by Itron, Inc. Extensive documentation is provided in the final project report (CEC-400-2006-005) and appendices posted on the CEC web site[15]. Itron maintains a website that provides additional info and extensive results of the modeling[16]. The data collected in this study also are available through LBNL's EnergyIQ online tool[17].

The survey included a stratified random sample of approximately 2,800 commercial *premises* in the areas served by Pacific Gas & Electric (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), Southern California Gas Company (SCG) and the Sacramento Municipal Utility District (SMUD). The premise is defined as "a single commercial enterprise operating at a contiguous location". Sample stratification was by utility service area, climate region, building type, and energy consumption level.

2.2.2.2 Healthcare Facilities

The number of premises sampled by type is provided on pp. 81-82 of the CEC report. The sample included 171 health care buildings (of 2791 total buildings); the division among service areas was 62, 69, 24, and 16 in PG&E, SCE, SDG&E and SMUD respectively. The specific type of each health care facility was recorded in the survey but results presented in the CEC report and on the Itron web site are resolved only to the level of the "healthcare" market segment. EnergyIQ allows users to benchmark against healthcare facilities with the following resolution (number of data points or premises in parentheses): hospital (79), clinic/outpatient care (27), medical/dental lab (10), and nursing home (50). Additionally, there are records for 47 medical/dental office buildings.

---

[13] www.eia.doe.gov/emeu/cbecs/enduse_consumption/intro.html
[14] www.eia.doe.gov/emeu/cbecs/cbec-eu2.html
[15] http://www.energy.ca.gov/ceus/index.html
[16] http://capabilities.itron.com/ceusweb/
[17] http://energyiq.lbl.gov/

2.2.2.3 Primary Data

The primary survey data are not available to the public. The data may be probed using the EnergyIQ online tool. EnergyIQ does not identify individual records from the CEUS database but it does allow users to view distributional results for total premise and resolved end-use energy intensities.

2.2.2.4 Analysis and Results

Primary data were analyzed (by Itron) as follows. Using software developed for this purpose, an energy simulation model was created for each premise based on the survey data. Simulated energy use for each facility was calibrated to actual energy consumption based on utility bills. The software also created load profiles and consumption estimates for electricity and natural gas by end-use and commercial market segment. The software allows evaluation of energy efficiency measures, weather, changes to rate schedules, and other alternatives to baseline usage patterns.

Results include floor stocks, fuel shares, electric and natural gas consumption, energy-use intensities (EUIs), and 16-day hourly end-use load profiles resolved for 12 commercial building categories and for each utility service area. Consumption estimates reflect total end use at the site including electricity generated on-site (and excluding any natural gas or other fuel used to generate that electricity). Results are posted on the Itron web site[18], accessible as interactive viewing options and downloadable data files.

As noted above, CEUS results are also viewable through the EnergyIQ benchmarking tool. The user specifies the desired data using a filters for building type, vintage, location, floor area and peer group (CEUS is currently the only active group). The user additionally specifies the desired energy metric (total electricity, total gas, total fuel, end use, or peak demand); the indicator (site energy, source energy, cost or emissions); and the output plot format (summary, range bar, ranked bar or distribution). End-use estimates are based on the calibrated modeling as described above and include lighting, heating, cooling, hot water, ventilation, office equipment, refrigeration and other categories.

Results from the CEUS 2002 study are described in a later section.

2.2.3 Commercial End-Use Surveys by California Utilities (1990s)

Previous to the 2002 statewide survey, CEUS studies were conducted by individual investor-owned utilities within their coverage zones as described below. Data from several studies conducted in the 1990s was compiled by LBNL into the Cal-Arch[19] online benchmarking tool, also described below.

2.2.3.1 CEUS in PG&E Service Areas, 1992-93 and 1996-97

The information provided below is taken from the following two reports that were downloaded from the PG&E web site[20] in summer 2008: PG&E Commercial Building Survey Report 1997, PG&E Commercial Building Survey Report 1999. These reports focus on summary results with minimal details provided about the study sample or methods used. The 1997 and 1999 reports cover the 1993-94 and 1996-97 surveys, respectively.

---

[18] http://capabilities.itron.com/CeusWeb/Overview.aspx
[19] http://poet.lbl.gov/cal-arch/
[20] http://www.pge.com/mybusiness/energysavingsrebates/analyzer/buildingreport/index.shtml

The 1993-94 study involved on-site surveys of over 2,000 commercial customers in PG&E service territory, including combined gas-electric, electric-only and gas-only customers. The report was based on analysis of 1,912 surveys. The 1996-97 study involved on-site surveys of almost 1,000 commercial customers selected to represent the population of electric service customers.

The surveys included information on building structures, business operations, equipment types, fuel choices, and operating schedules. Information is presented about the floor area (square foot, sf) of each business type by climate zone, the distribution of facilities in size (sf) bins, year of construction, ownership and type of heating and cooling system.

The hospital category (business type) includes SIC codes 805-807 which include the following: skilled nursing & intermediate care (805); general medical and surgical hospitals plus psychiatric and specialty hospitals (806); and medical and dental labs (807). Various medical offices (801-804), home health care, and outpatient / dialysis facilities (809) were grouped with other offices. It is not explicitly clear if information and results for "hospitals" applies only to the hospital building or to all buildings that comprise the facility, i.e. including medical office buildings. The breakdown of buildings within the hospital business type is not stated (all could be hospitals).

End-use intensities were calculated with SitePro simulation software; this package used DOE-2 for HVAC loads and relied on engineering models for other end uses. All results are for site energy with electricity and gas use calculated separately. Heating and cooling energy use intensities are presented in relation to the areas (sf) served, not to total building area (as appears to be the case for the 2002 CEUS and all CBECS datasets).

The following table compiles the total building EUI estimates presented for "hospitals" in the two PG&E CEUS reports. These appear to be estimates for the population of hospitals in PG&E service area, not just the values for the sampled buildings. Though not stated explicitly, the EUIs appear to be calculated for site energy. Estimates of specific end-use EUIs in these studies are not presented or discussed here because the 2002 study provides a larger sample and includes much more extensive documentation. The total building EUIs are compared below to results from the 2002 CEUS and 2003 CBECS studies.

Table 2. Estimated Energy Use Intensities for Hospitals in PG&E Service Area

	Electricity	Electricity	Gas	Total
Report (data years)	kWh/sf-yr	kBtu/sf-yr	kBtu/sf-yr	kBtu/sf-yr
PG&E 1999 (1996-97)	21.2	72	137	209
PG&E 1997 (1992-93)	20.2	69	97	166

2.2.3.2 Cal-Arch Benchmarking Tool

Cal-Arch is a commercial building benchmarking tool developed by Lawrence Berkeley National Lab using data from commercial end-use surveys (CEUS) conducted by California investor-owned utilities in the 1990s. Included in Cal-Arch are electricity use data from SCE surveys conducted in 1992 and 1995 and PG&E surveys conducted in 1992-93 and 1996-97. The latter two studies are described in the previous section. The 1995 SCE study included hospitals

and clinics whereas the 1992 study did not include any health care[21]. The data collected in these studies are compiled in a web-based benchmarking tool[22].

The tool is designed to facility comparison between information entered by a user and the actual data from the CEUS studies. Calculated energy use intensities are unadjusted for climate but resolved into 4 climate zones (north coast, south coast, central valley and desert/mountain). Comparisons can be made by climate zone using the facility zip code or statewide (no zip code entered by user).

Queries of the tool indicate the following sample sizes for healthcare buildings: electricity data for 81 inpatient and 43 outpatient, natural gas data for 16 inpatient and 7 outpatient facilities. The SCE sample includes only electricity customers and appears to have acquired data on a much larger number of facilities than does the PG&E area. Whole building data are provided only for those buildings in which all energy data are available, i.e. electrical data for all-electric buildings or both electric and natural gas (plus other fuels). A statewide query/comparison provides results for 12 inpatient and 22 outpatient buildings.

Available data for inpatient facility whole-building energy use indicate that 9 of the 12 hospitals for which both natural gas and electricity data are available have a whole-building EUI of 200 kBtu/sf-yr (site) or greater. The whole building EUI for outpatient facilities is positively skewed, with a median value of 41 kBtu/sf-yr (mean value not provided).

Documentation comparing this benchmarking tool and underlying data to Energy Star Portfolio Manager is available at the site[23].

2.2.4 Energy Star for Health Care & Portfolio Manager

Energy Star for Health Care is an EPA program which provides information and a suite of tools to facilitate energy efficiency improvements in the healthcare sector[24]. The centerpiece of the program is the facility level Portfolio Manager benchmarking system[25]. Portfolio Manager (PM) features an energy performance rating scale of 1-100 that compares the actual facility level energy use (based on electricity, natural gas, and other fuels) to a nationwide database of similar data. Separate rating systems are developed for acute care hospitals and medical office buildings. Facilities receiving scores of 75 or higher get the Energy Star rating.

The Portfolio Manager (PM) rating system calculates an adjusted total source energy use intensity (kWh/sf-yr) based on total energy use, floor area and other factors that can affect energy loads (the model actually calculates the natural log of the adjusted or "expected" source energy use intensity). These factors are identified through a multiple regression analysis of an existing dataset. The resulting multiple regression model is used to develop a national, weighted distribution of facility level source energy use intensities (EUI). This distribution is then fitted to a probability density function. When facility specific information is entered into Portfolio Manager, the same regression model is applied to develop an adjusted facility EUI and the associated score is provided to the user. In its current configuration, the regression model and scale are fixed; data provided by users are not used to update the database. In principle, the algorithm could be updated and other databases could be used with this methodology.

---

[21] http://poet.lbl.gov/cal-arch/ceus.html
[22] http://poet.lbl.gov/cal-arch/compare.html
[23] http://poet.lbl.gov/cal-arch/LBNL_57364.benchmarking_review.040105.v2.draft.pdf
[24] http://www.energystar.gov/index.cfm?c=healthcare.bus_healthcare
[25] http://www.energystar.gov/index.cfm?c=healthcare.bus_healthcare_benchmark

EPA has posted technical documents[26] describing the benchmarking models used for various building types including acute care hospitals (EPA, 2001) and medical office buildings (EPA, 2004).

The following information is provided in the technical description for acute care hospitals. The regression model for hospitals uses data from the Electric Power Research Institute (EPRI) Energy Benchmarking Survey completed in 1997. This database contains information on energy consumption and building characteristics for 701 Hospitals. Following application of data filters (refer to documentation for details), there are 493 records, distributed as follows by facility category: acute care/children's hospitals (415), cancer centers & clinics (4), skilled nursing (45), psychiatric hospitals (10), rehabilitation centers (19). The regression model used all of these data to identify the following seven characteristics as "key explanatory variables" that are used to calculate the expected natural log of source EUI for a given Hospital:

- Natural log of gross square foot
- Is the facility an Acute Care/Children's Hospital (1 = yes)
- Does the Hospital provides tertiary care (1 = yes)
- Natural log of the number of beds
- Natural log of the maximum number of floors
- Presence of an above ground parking facility (1 = yes)
- Sum of heating and cooling degree days "

The following information is provided in the technical description for medical office buildings. The regression model for medical office buildings uses data from the 1999 CBECS survey. This database contains 93 records that can be defined as medical office buildings. After application of data filters, 82 records were included in a multiple regression analysis that identified the following explanatory variables:

- Natural log of gross square foot
- Natural log of number of workers
- Natural log of weekly operating hours
- Heating degree days times Percent of the building that is heated
- Cooling degree days times Percent of the building that is cooled

The Energy Star web site describes the use of source energy (EPA, 2007) that and includes a links to additional technical documentation[27].

The Energy Star web site also includes background information on health care sector energy use and commercial building energy efficiency, plus links to other energy efficiency resources.

2.2.5 Johnson Controls 2007 Energy Efficiency Indicator Survey

This survey was conducted for Johnson Controls by the Kramer-Crasselt Brand Planning Department. A final report dated April 18th, 2007 is posted on the IFMA research website[28]. The report (Cramer-Krasselt, 2007) summarizes responses of 1249 individual including facility managers and company executives with knowledge of facilities. Results of many survey questions are presented by industry; key results for the health care sector (90 respondents) are presented below.

---

[26] http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager_model_tech_desc
[27] http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_benchmark_comm_bldgs
[28] http://www.ifma.org/tools/research/survey_results.cfm

- Energy (electricity and natural gas) costs for health care facilities comprised fractions of total expenses that were similar to other industries; 6% reported energy costs ≥20% of total expenses and 16% reported energy costs of 10-20% of expenses (note that 25% reported not knowing how much energy costs are as fraction of total).
- Of all industries, health care had the highest rate of respondents (76%) expecting to make energy efficiency improvements in the coming year.
- Health care respondents on average expected 10% of capital expenditures to go toward energy efficiency; this is among the highest by industry. Ten percent of health care respondents projected that >25% of capital expenditures would be spent on energy efficiency.
- About 80% of health care respondents expected to use operating budgets to fund energy efficiency improvements; similar levels were observed for education, research labs and manufacturing plants and these were higher than planned by other industries.
- Health care respondents expected to spend on average about 6% of operating funds on energy efficiency; this is the highest for any industry and substantially higher than the 6% average for all respondents.
- Health care respondents expected a 10% reduction in energy consumption; this is slightly higher than respondents from other industries.
- Thirty-nine percent of health care respondents believed their energy cost per square foot will decrease, compared with 22-29% making this projection for other industries.
- Health care companies had the highest rate (25%) of respondents reporting that energy management was "extremely important"; only 8% of health care respondents thought it "not" or "not at all" important.
- Energy consumption data was reported to be reviewed more frequently on average by health care companies relative to others, owing primarily to the larger fractions of health care companies reviewing daily (7%) or weekly (12%); consumption data were reviewed monthly by 41% and quarterly by 20% of health care companies.
- All types of facilities were paying more attention to energy than they were a year ago, but health care had the lowest rate of paying "much more attention"; this may reflect the fact that many of the health care companies were already very attentive to energy issues.
- The average expected return on investment period (years) was higher for health care (5.3 y), education (5.2 y) and research/laboratories (4.8 y) compared to other facility types. Thirty-one percent of health care respondents expected return on investment to take 6 years or greater.
- Energy efficiency was a major consideration in 77% of retrofit or new construction projects across all facility types, and 75% of health care companies.
- The motivation for energy efficiency improvements was similar across all industries; for health care, the motivation was mostly or entirely for cost savings in 27% of cases, somewhat more for cost in 26% of cases and equally for cost and environment in 33% of cases.

2.2.6 Energy Efficiency Incentive Programs

A number of utilities offer audit and incentive programs that target hospitals and other healthcare facilities. Notable are programs run by Pacific Gas & Electric (PG&E) and Southern

California Edison (SCE) in California and the Northwest Energy Efficiency Alliance in the northwest U.S. Audits conducted for these programs contain information about energy use and energy reduction opportunities. Estimates or measurements of energy savings from specific measures are documented in reports having varying levels of accessibility; the reports are confidential but may be obtainable with permission of the facility owners and the program administrator.

2.3 Energy Expenditures in Health Care Facilities

Estimates of total energy expenditures for U.S. healthcare facilities and buildings housing other activities are provided in CBECS data table C4 (Expenditures for Sum of Major Fuels). These estimates, presented below, indicate that hospitals spend more per square foot of floor space than all other types of buildings with the exception of food service and food sales.

Table 3. Estimated Energy Expenditures for U.S. Buildings (CBECS 2003, Table C4).

Principal Building Activity	Buildings (thousand)	Total floor area (10^6 sf)	Floor area per bldg. (10^3 sf)	Total spending ($\$10^6$)	Spending per bldg ($\$10^3$)	Spending per sf bldg area ($)	Spending per 10^6 Btu (dollars)
Education	386	9,874	25.6	12,008	31.1	1.22	14.64
Food Sales	226	1,255	5.6	4,990	22.1	3.98	19.91
Food Service	297	1,654	5.6	6,865	23.1	4.15	16.07
Health Care	**129**	**3,163**	**24.6**	**7,440**	**57.8**	**2.35**	**12.53**
Inpatient	**8**	**1,905**	**241.4**	**5,329**	**675.4**	**2.80**	**11.23**
Outpatient	**121**	**1,258**	**10.4**	**2,111**	**17.5**	**1.68**	**17.74**
Lodging.	142	5,096	35.8	7,445	52.3	1.46	14.61
Retail (Non-Mall)	443	4,317	9.7	5,980	13.5	1.39	18.75
Office	824	12,208	14.8	20,841	25.3	1.71	18.39
Public Assembly	277	3,939	14.2	5,790	20.9	1.47	15.65
Public Order/Safety	71	1,090	15.5	1,917	27.2	1.76	15.18
Religious Worship	370	3,754	10.1	2,457	6.6	0.65	15.06
Service	622	4,050	6.5	4,779	7.7	1.18	15.33
Warehouse/Storage	597	10,078	16.9	6,894	11.5	0.68	15.12
Other	79	1,738	21.9	4,420	55.7	2.54	15.47
Vacant	182	2,567	14.1	751	4.1	0.29	14.02

The Johnson Controls 2007 survey of facility managers (Cramer-Krasselt, 2007) provides estimates of energy expenditures in relation to total operational expenditures for healthcare and other types of facilities. These data suggest that for a non-negligible number of healthcare facilities, energy accounts for a moderate to large fraction of total operating expenses.

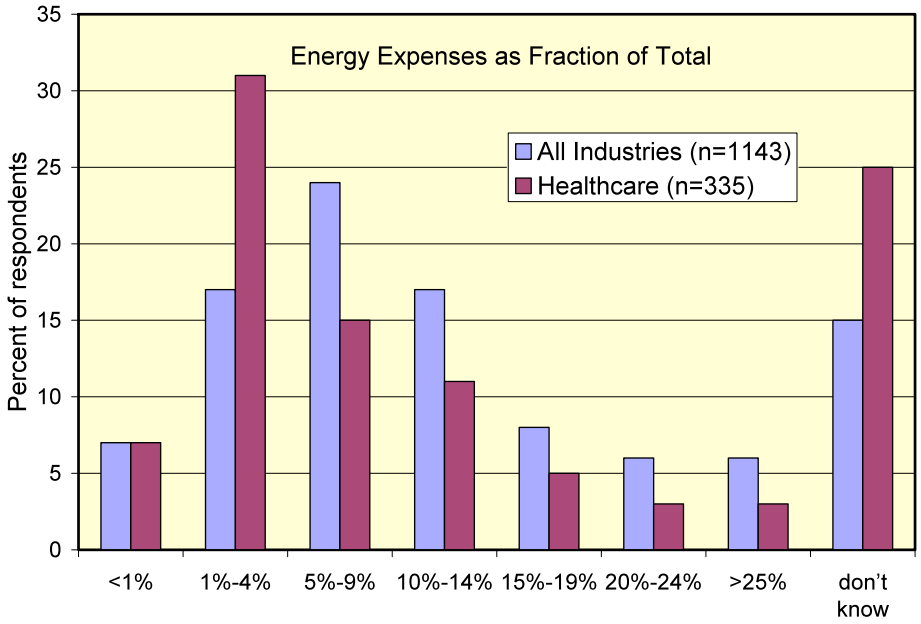

Figure 1. Fraction of total expenses attributed to energy, Johnson Controls 2007 survey of facility managers (Cramer-Krasselt, 2007).

2.4 Energy Use in Health Care Facilities

2.4.1 Total Site Energy Use

Information on total energy use in healthcare buildings is available from both the CBECS and CEUS studies. Shown in the table below are results from CBECS; these include the estimated mean site energy use intensities for all inpatient (hospitals) and outpatient healthcare buildings on a nationwide level (from Table E2) and resolved by climate zone (from Tables C10a, C20a, and C30a).

Table 4. Total building energy use intensities (EUI) for health care buildings, CBECS 2003.

Site energy, kBtu/sf-yr	US mean	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
Heating DD[1]	-	>7K	5.5-7K	4-5.5K	<4K	<4K
Cooling DD[1]	-	<2K	<2K	<2K	<2K	<2K
Health Care	188	202	206	191	172	168
Inpatient[2]	249	246	283	Q	215	Q
Outpatient[3]	95	Q	102	Q	Q	Q

[1] Base 65 ºF.
[2] Based on survey data from 217 hospitals.
[3] Based on survey data from 52 diagnostic medical offices and 92 clinic/outpatient facilities.

The table below provides results for the same metric - total site energy use - for records of all healthcare premises in the CEUS database available through EnergyIQ.

Table 5. Total building energy use intensities (EUI) for health care buildings, CEUS 2002.

Median for California (CEUS 2002)[1]	Data points[2]	Median[3] site kBtu/sf-yr	Mean[3] site kBtu/sf-yr
Hospitals	79	234	231
Nursing Homes	50	113	121
Outpatient/clinic	27	44	60
Med/Dental Labs	10	14	64
Med/Dental Office	47	41	43

[1] Via EnergyIQ (www.energyIQ.lbl.gov).
[2] Number of premises surveyed; used as basis to estimate population distribution and median value shown.
[3] Median directly from EnergyIQ site; mean calculated from tabular data.

The two surveys provide roughly consistent EUI estimates for hospitals. The CBECs data indicate a moderate degree of climate dependence. Since most of California falls within zone 4 (<2000 and <4000 heating and cooling degree-days, respectively), this is the most relevant for comparison to CEUS results. The California hospital total is about midway between the CBECS inpatient estimate for climate zone 4 and the nationwide total, and within about 7% of each. Given the many uncertainties associated with both surveys, this represents substantial agreement.

Both the CBECS and CEUS results show much higher site energy intensities for hospitals relative to other healthcare buildings. However, the estimates for outpatient facilities are much higher in the nationwide CBECS dataset compared with CEUS. The difference between median and mean values for outpatient and clinics in CEUS indicates the importance of some clinics having very high energy intensities. The difference between CEUS and CBECS could therefore result from the types of facilities sampled in each study.

2.4.2 Site Energy by End Use

Both CBECS and CEUS provide estimates of end-use energy intensities. The table below presentes estimates of site energy resolved by end-use for all major fuels. For CBECS the data (from Table E2) represent an average breakdown for all hospitals, whereas for CEUS the breakdown is tied to the median energy intensity. The end-use intensity estimates are roughly similar for many categories. (The relative contributions of various end-uses to total building energy consumption will be addressed in a subsequent section.) More site energy was used for space heating in the CBECS sample relative to CEUS; this is consistent with the overall warmer climate (CBECS climate zone 4) in California relative to the U.S. as a whole. Other major end-uses having substantially different site intensity values were lighting (higher in CBECS) and “other” (higher in CEUS).

Table 6. Hospital end-use energy intensities, CBECS 2003 and CEUS 2002.

Site energy, kBtu/sf-yr	CBECS Inpatient	CEUS Hospitals	CBECS Inpatient	CEUS Hospitals
	Site energy, kBtu/sf-yr		Fraction of total	
Data points	217	79		
Total	249.2	234.1		
Space Heating	91.8	64.6	37%	28%
Cooling	18.6	22.7	7%	10%
Ventilation	20.0	23.8	8%	10%
Water Heating	48.4	38.7	19%	17%
Lighting	40.1	24.9	16%	11%
Cooking	5.6	8.5	2%	4%
Refrigeration	2.0	2.1	1%	1%
Office Equipment	4.7[1]	4.9	2%	2%
Other	18.1	43.9	7%	19%

[1] Sum of "office equipment" value in Table E2 and "computer" value in Table E4. In Table E2, energy intensity for computers is listed as 1.0 for all building types. Values for office equipment are roughly the same in E2 and E4.

The next table provides the same information for outpatient facilities and clinics. As indicated in Table 6 above and shown in Figure 10 (presented in subsequent section), the CEUS distribution of EUI in outpatient facilities and clinics is positively skewed, i.e., a few highly energy intensive facilities have a substantial effect on the mean for the population. We queried the available data and calculated an estimated mean site EUI for each end-use category; these are presented along with the end-use EUIs that are linked to the median total site EUI, as provided by EnergyIQ. The estimated mean EUIs are similar in CEUS and CBECS for many end-uses. The higher total site EUI in CBECS can be attributed entirely to space heating, with an EUI that is five times higher than the mean estimate for CEUS. CBECS also had a moderately higher site EUI for lighting and CEUS had higher EUIs for cooling and water heating.

Table 7. Outpatient / clinic end-use energy intensities, CBECS 2003 and CEUS 2002.

Site energy, kBtu/sf-yr	CBECS (mean)	CEUS (median)	CEUS (mean)[1]	CBECS (mean) %	CEUS (median) %	CEUS (mean) %
Data points	144	27	(varies)			
Total Energy	94.6	43.5	63.6			
Space Heating	38.1	6.3	7.6	40%	14%	12%
Cooling	7.2	5.9	8.9	8%	14%	14%
Ventilation	3.3	2.9	3.5	3%	7%	6%
Water Heating	2.5	5.6	7.3	3%	13%	12%
Lighting	22.6	11.5	16.2	24%	26%	25%
Cooking	Q	0.4	0.6	-	1%	1%
Refrigeration	3.5	2.4	3.4	4%	5%	5%
Office Equipment	3.9[1]	3.2	4.4	4%	7%	7%
Other	13.2	5.5	11.8	14%	13%	19%

[1] Calculated from distributions of EUIs for individual end-uses. "Process" end-use excluded for insufficient data.
[2] Sum of "office equipment" in Table E2 and "computer" in Table E4. In Table E2, EUI for computers is listed as 1.0 for all building types. Office equipment EUIs are roughly the same in E2 and E4.

Source energy end-use energy intensities for hospitals, outpatient facilities and other healthcare building types are examined in the following section.

2.4.3 Comparison of Site and Source Energy Use

Source energy provides the most robust and meaningful framework for comparing use of energy in different forms (electrical, natural gas, fuel oil, etc.) at the site. Comparisons of site vs. source energy show how this adjustment shifts the relative importance of energy use by major services. Source energy is also a good proxy for site energy costs, as electricity pricing reflects the cost of primary fuel used in generation.

To illustrate the shift from site to source energy, the EnergyIQ tool was queried to provide both site and source energy use, in the same units (kBtu/sf-yr) for all hospitals in California. The figure below presents stacked bars showing the site and source energy intensities of various end-uses (services) in California hospitals; also shown are the site energy values for CBECS. From the CEUS analysis, total source energy intensity was about a factor of 2 higher than site energy. The magnitudes of space heating and domestic hot water (DHW) - both powered mostly by natural gas or oil - increased a bit; this likely reflects the electricity used for pumps in these systems. Much larger increases (from site to source) were observed for all of the electrical systems: cooling, ventilation, lighting, etc.

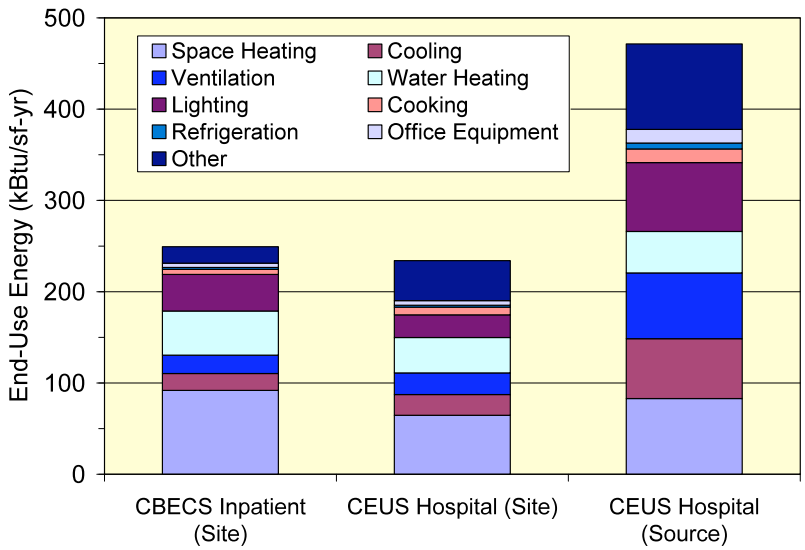

Figure 2. Site and source end-use apportionment for hospitals, CBECS 2003 and CEUS 2002.

2.4.4 Healthcare vs. Other Buildings

The figure below shows healthcare building site energy use intensity relative to other buildings, based on CBECS 2003 estimates for the U.S. building stock. Also shown for context is the estimated total floor space of each building type. Inpatient health care (primarily hospitals) is the second most energy intensive type of building, second only to food service (restaurants).

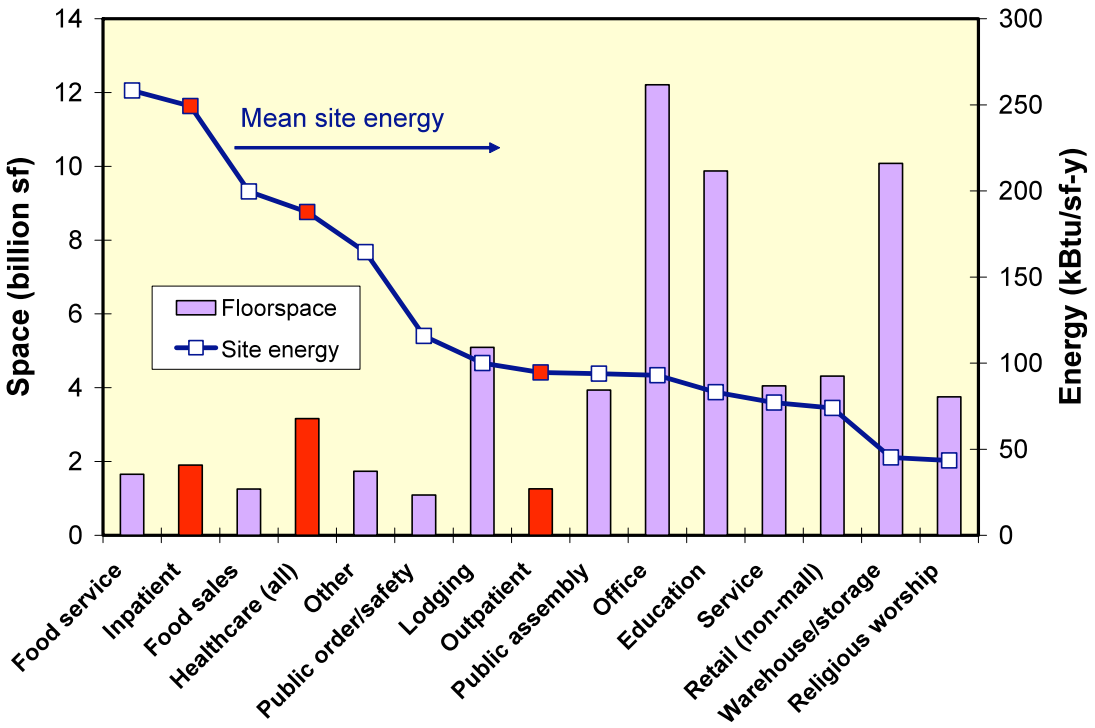

Figure 3. Estimated site energy intensity and floor space of U.S. buildings, CBECS 2003.

The figure below shows estimated median source energy use for California buildings. Note that this plot differs from above in four ways: (1) California below vs. U.S. above, (3) source energy below vs. site energy above, (3) median values below vs. mean above, and (4) the estimates below were calculated with a different methodology (CEUS) compared with CBECS above. The data are provided in these forms to allow use of data as publicly available. The CEUS data show that even with the different analysis technique and in terms of source energy, hospitals are the second most energy intensive buildings, behind restaurants. Likewise, outpatient health care facilities have annual source energy intensities similar to office buildings and lodging.

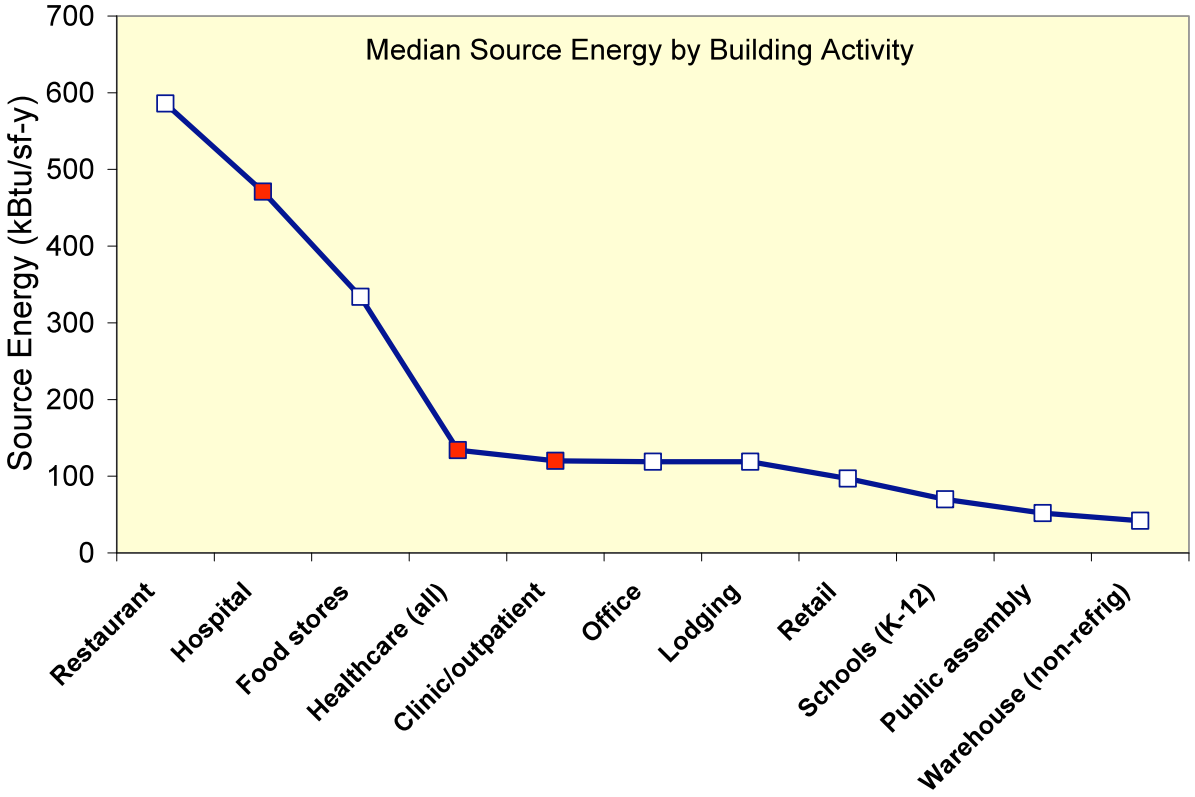

Figure 4. Estimated source energy intensity of selected California buildings, CEUS 2002.

2.5 End-Use Apportionment for California Health Care Buildings

The next series of figures show the end-use apportionment, as a fraction of total energy use, for both site and source energy for several types of health care facilities in California. The hospital apportionment shows how shifting from site to source can shift the focus of energy efficiency efforts. On a site energy basis, space heating accounts for 28% of the total, nearly three times the values for cooling, ventilation and lighting; DHW is the second largest energy user at 17%. But on a source energy basis, energy use for these services is more similar, ranging from about 10% to 18%. Several of the categories grouped into “other” above are listed separately in this figure.

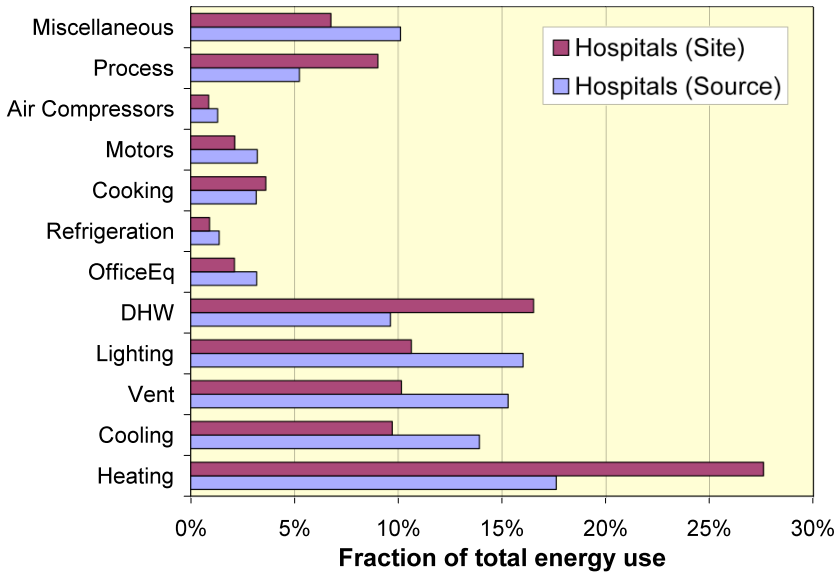

Figure 5. Hospital energy end-use apportionment, site and source basis (CEUS 2002 data).

The analogous figures for nursing homes, outpatient facilities and medical office buildings are provided below. Even on a source energy basis, domestic hot water is still the largest end-use (at 26%) in nursing homes. Lighting is next followed by heating, cooling and ventilation. Cooking and refrigeration are more important in nursing homes relative to hospitals.

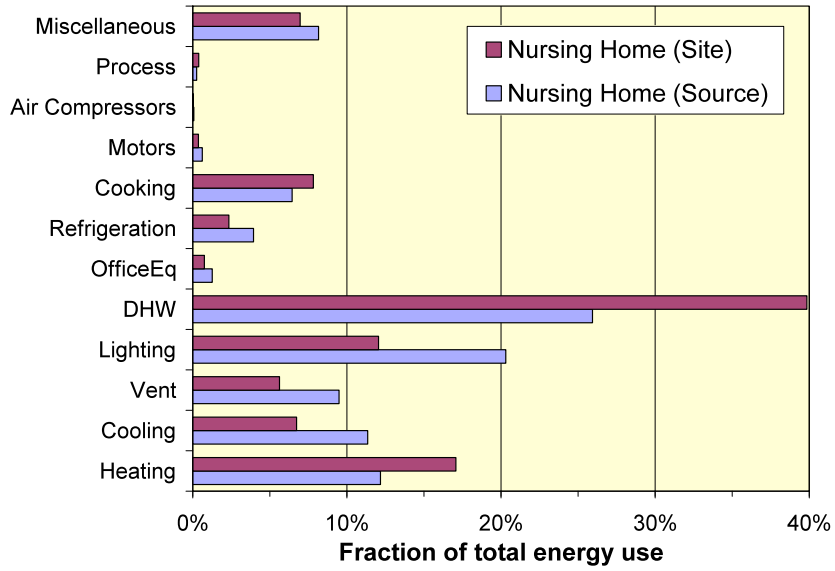

Figure 6. Nursing home energy end-use apportionment, site and source basis (CEUS 2002 data).

The end-use attribution looks very different for outpatient facilities. Lighting accounts for the largest fraction at 31%, followed by cooling at 16%. Refrigeration and office equipment each account for similar levels as DHW, ventilation and heating. The breakdown is less sensitive to site vs. source energy accounting because electricity dominates total energy use. The breakdown for medical office buildings is similar to outpatient facilities.

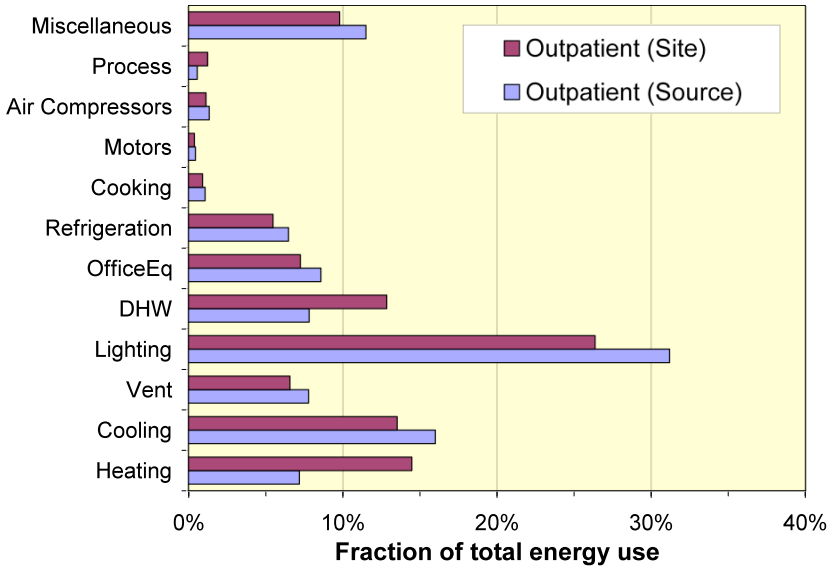

Figure 7. Outpatient/clinic energy end-use apportionment, site and source basis (CEUS 2002 data).

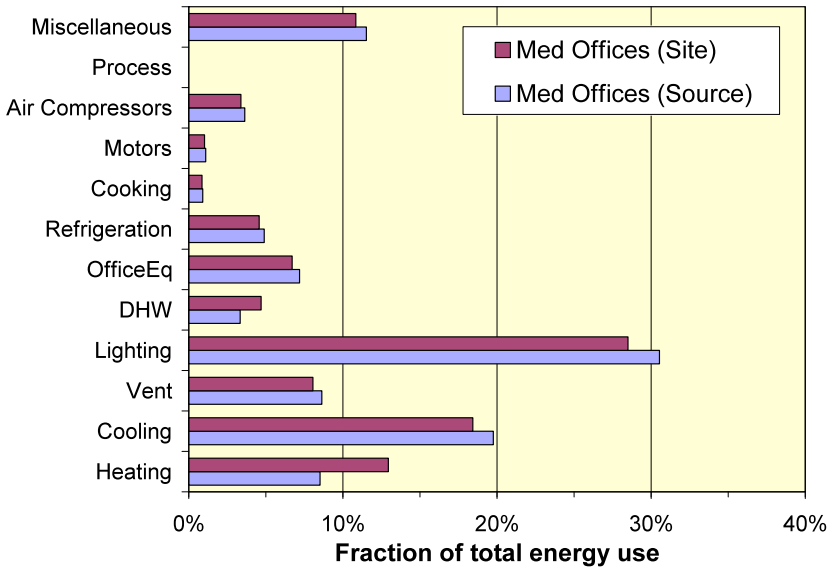

Figure 8. Medical & dental office energy end-use apportionment, site and source basis, CEUS 2002.

2.6 Energy Intensity Distributions: Total Energy Use

This section presents CEUS results, via EnergyIQ, showing the estimated distribution of total source energy use for health care buildings throughout California.

According to these estimates, source energy use intensity is normally distributed among California hospitals with a median of 471 kBtu/sf-yr.

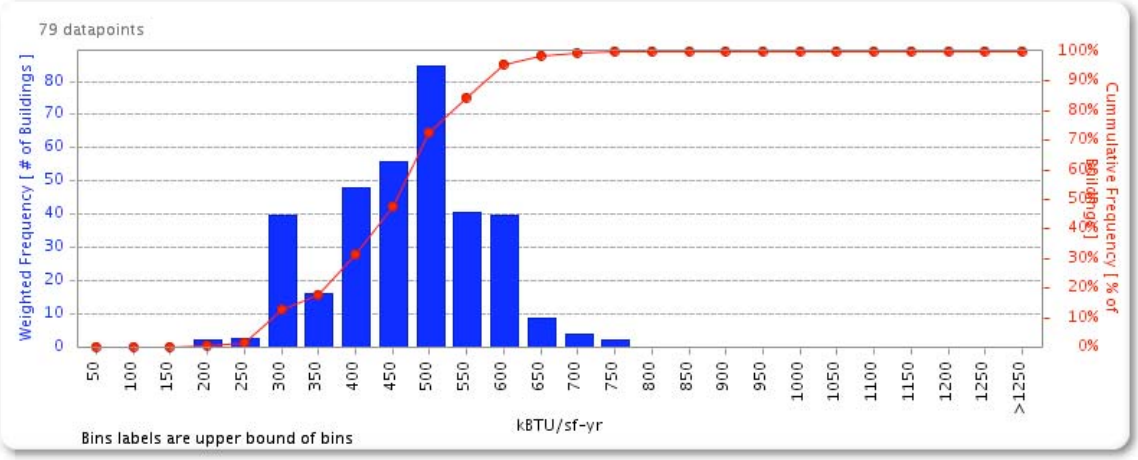

Figure 9. Estimated source energy use intensities for California hospitals, CEUS 2002.

Clinics and outpatient facilities are estimated to have a more skewed distribution of total source energy use, as shown below. This may reflect large variations in the services provided; some outpatient facilities offer extensive diagnostic & treatment services including outpatient surgery centers. These estimates point to the need for careful characterization of such facilities for the purpose of energy benchmarking.

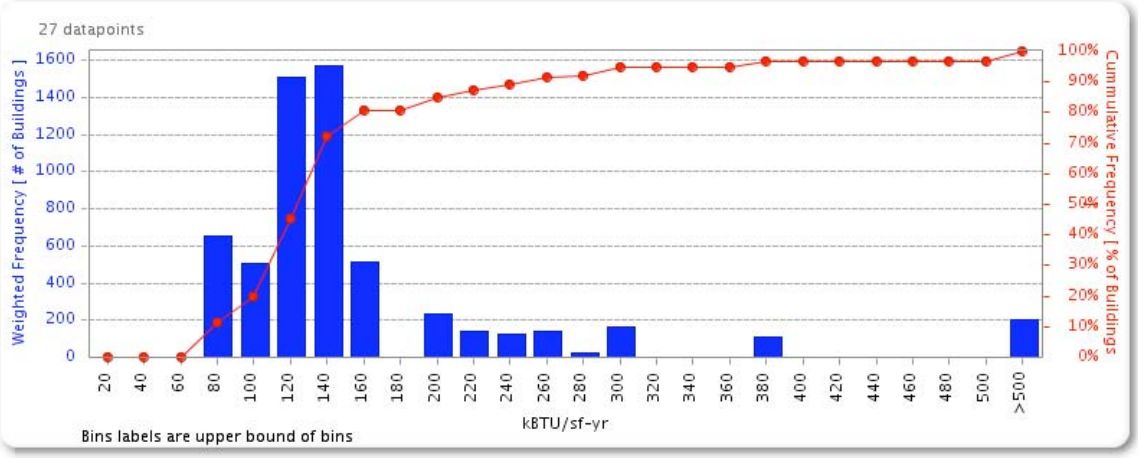

Figure 10. Estimated source energy use intensities for California outpatient/clinics, CEUS 2002.

The estimated distribution of energy use among California nursing homes is bimodal, with one large concentration in the range of 140-160 kBtu/sf-yr and another in the range of 220-240 kBtu/sf-yr. As with outpatient facilities, this distribution may reflect differences in the services being provided at nursing homes throughout the state.

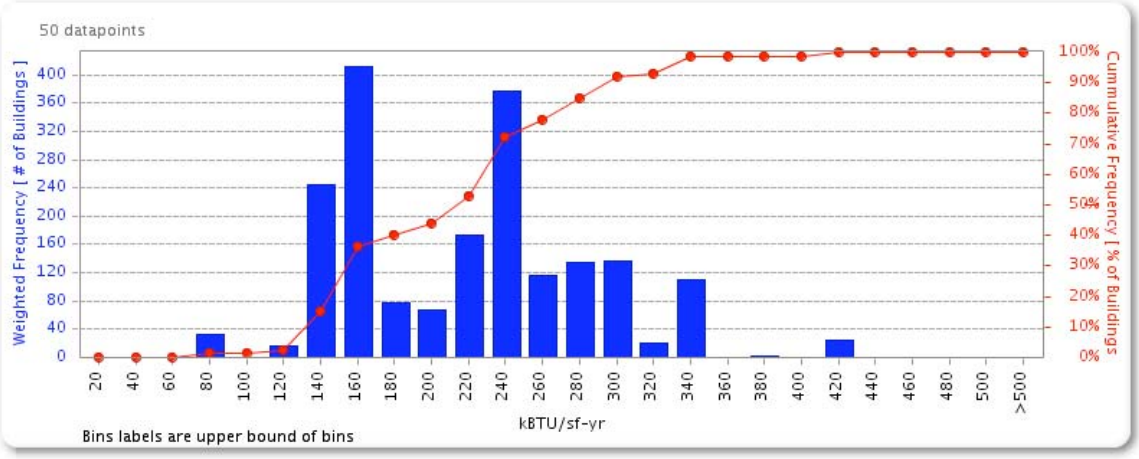

Figure 11. Estimated source energy use intensities for California nursing homes, CEUS 2002.

The estimated distribution of energy use for medical and dental labs in California is based on only 10 facilities and therefore is highly uncertain. The mode (large peak) in the lowest bin is particularly questionable as this level is lower than that observed for most other buildings.

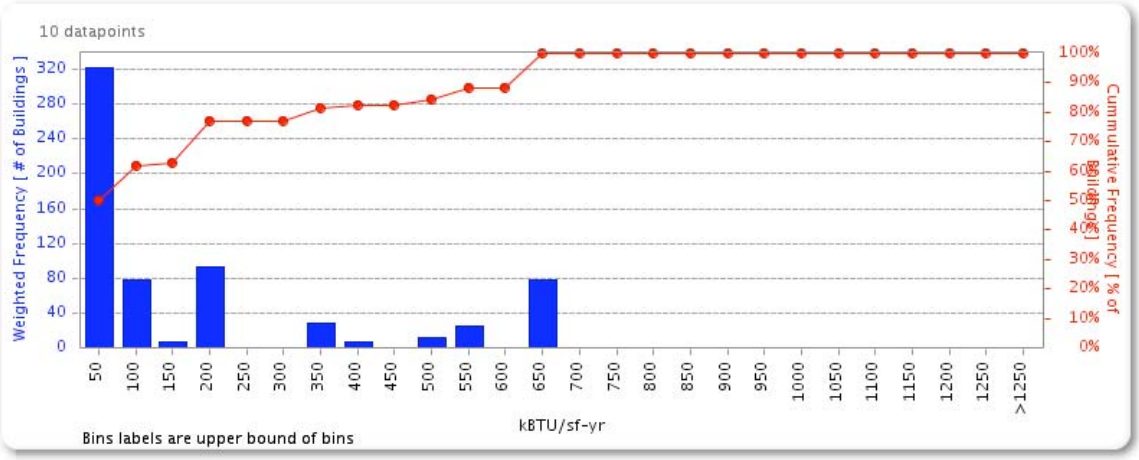

Figure 12. Estimated source energy use intensities for California medical and dental labs, CEUS 2002.

The figures below display estimated distributions of source energy use intensity for California medical and dental office buildings (MOB) and all types of office buildings with floor areas less than 150,000 sf. This cut is used because 45 of the 47 MOBs have floor areas <150,000 sf. These results suggest that MOB energy use intensity is very similar to other types of offices.

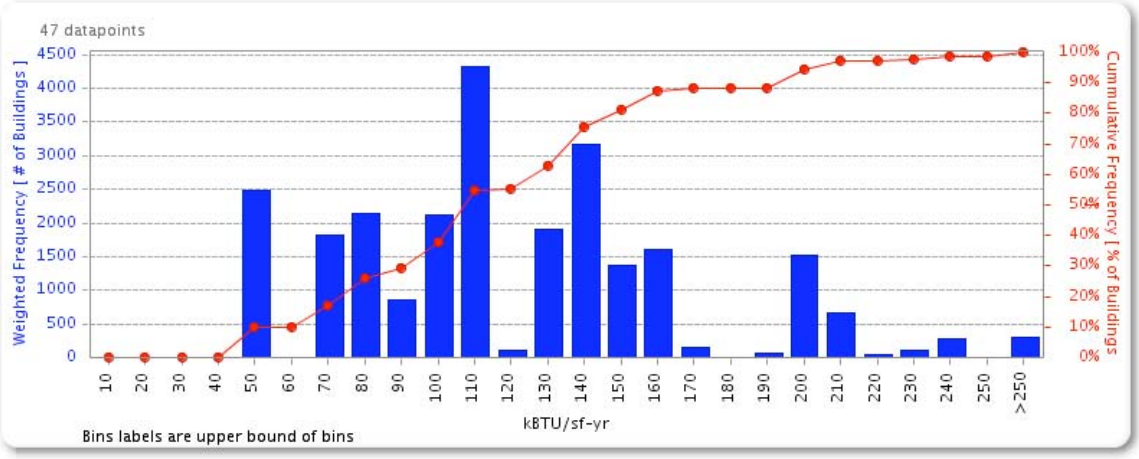

Figure 13. Estimated source energy use intensities for California medical & dental offices, CEUS 2002.

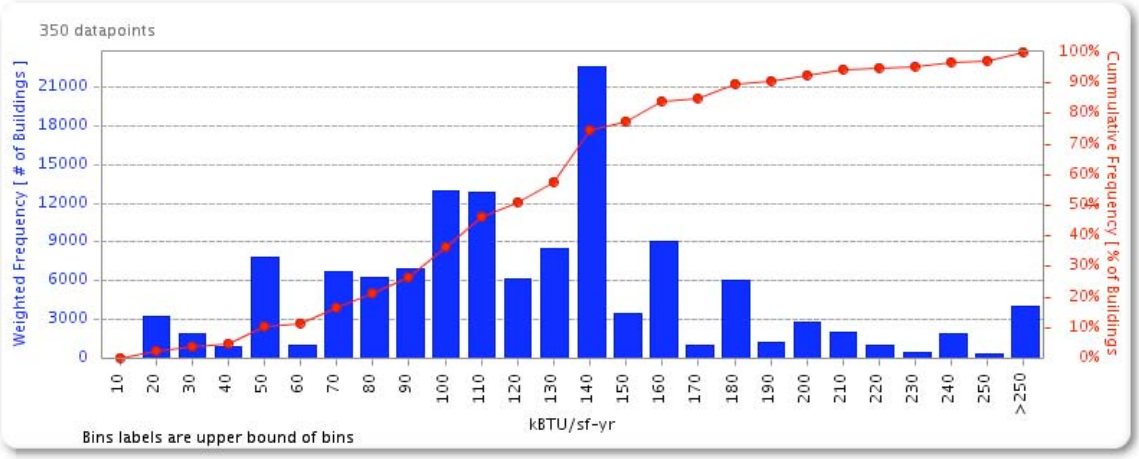

Figure 14. Estimated source energy use intensities for California office buildings <150,000 sf, CEUS 2002.

2.7 Information about Major Energy Using Systems

The CBECS and CEUS surveys include numerous questions about building characteristics, equipment, system design, and operations related to ventilation, cooling, heating, domestic hot water, other services (e.g., refrigeration), lighting and other electronic equipment (e.g. computers). The ASHE Healthcare Energy Project (ASHE, 2004) included an abbreviated set of questions about the major systems and a more expansive list of questions about energy conservation features. Results from the ASHE survey are compiled in the publicly available report. CEUS data can be queried by building type using the EnergyIQ benchmarking tool. CBECS data are available through the public use "microdata" files and EnergyIQ.

The following sub-sections list the information that is available for each major energy-using system, by survey source. The following major systems are included: lighting, ventilation, cooling, space heating and steam (grouped together in CBECS), domestic hot water, and electrical equipment. For CBECS, we list data descriptions from the layouts and formats

document. For ASHE, we note the survey question number for the relevant information. In light of their relevance to the focus of this report, we first present summary results for many of the energy conservation questions from the ASHE survey. For all other systems, we initially note only the information that is available. Results from queries of these data sources may be included in subsequent versions of this document.

2.7.1 Energy Management and Conservation

CEUS: EnergyIQ does not provide information on energy conservation features.

CBECS FILE 3:

- `EMCS8 Energy management and control system 190- 190 $YESNO`

ASHE:

- 10. Does facility have energy saving performance contracts: 16% yes
- 12. In what capacity have you worked with ESCOs:
    - 67% no relationship
    - 9% financed energy efficient equipment
    - 16% installed energy efficient equipment
    - 8% other
- 13. Participation in supply-side management:
    - 42% reviewed rates
    - 30% audited consumption
    - 22% had variable rate pricing
    - 6.6% had real-time pricing
    - 24% reported “none”
- 14. Type of cogeneration used:
    - 89% do not cogenerate
    - 1.7% reciprocal engines
    - 1.7% turbines
- 15. What are you doing with the waste heat:
    - 0.8% absorption cooling
    - 4.1% high-pressure steam
    - 1.7% other
- 16. Amount of energy you are generating and buying
- 17. Participation in demand-side management: 49% yes
- 18. Are EMCS/BAS in use: 87% yes
- 19. Year EMCS/BAS installed:
    - Pre-1997: 31%
    - 1997-1999: 11.6%
    - 2000: 6.6%
    - 2001: 9.9%
    - 2002: 17.4%
- 20. Areas covered by EMCS/BAS:
    - Air handlers: 87%
    - Fan/pump speed control: 71%
    - Chiller plant optimization: 71%

    - VFDs: 69%
    - Humidity control: 64%
    - Hot water systems: 48%
    - Boilers: 44%
    - Per room temp schedule: 30%
    - Exterior lighting control: 17%
    - Peak demand limiting: 12%
    - Interior lighting control: 9.9%
- 21. Condition-based management: 22% yes
- 24. Main equipment replaced in last 5 years:
    - Air handling: 50%
    - Cooking: 25%
    - Cooling: 56%
    - Heating hot water: 25%
    - Laundry: 12.4%
    - Water heating: 33%
- 25. HVAC conservation features installed in last 5 years:
    - Economizer: 36%
    - EMCS: 40%
    - HVAC maintenance: 52%
    - VAV system: 48%
    - None: 22%
- 26. Building shell conservation features installed in last 5 years:
    - Shading or awnings: 13%
    - Insulation: 17%
    - Landscaping: 12%
    - Multi-paned doors (5.8%), windows (19%)
    - Seals: 17%
    - Tinted/reflective/shaded glass: 29%
- 27. Lighting conservation features installed in last 5 years
    - Electronic ballasts: 77%
    - Reduced wattage: 59%
    - Relamping: 54%
    - Occupancy sensors: 42%
    - Improved reflectors: 26%
    - Dimmers: 20%
    - Timers: 19%
    - Daylighting: 6.6%
- 28. O&M procedures used for HVAC system
- 29. O&M procedures used for water heating system
- 30. O&M procedures used for cooling towers
- 31. O&M procedures used for lighting
- 32. O&M procedures used for building envelope
- 33. O&M procedures used for cooking equipment
- 34. O&M procedures used for laundry equipment
- 36. Year of last energy audit:

    - Pre-1997: 24%
    - 1997-1999: 14%
    - 2000: 7.4%
    - 2001: 9.1%
    - 2002: 15.7%
- 37. Who performed audit:
    - Consultant: 38%
    - ESCO: 12%
    - Internal: 9.9%
    - Energy supplier: 9.9%
- 38. What measures were recommended and when were they implemented?
- 39. What recommended measures were not implemented and why?

2.7.2 Lighting

CEUS info:
- Lamp
- Ballast
- Control
- Hours of Use

ASHE:
- 8i. primary lighting types (>10%)

CBECS:
- `LTOHRP8 Percent lit when open 43- 45 MISS3CH.`
- `LOHRPC8 Lit when open category 47- 47 $LIT1CAT.`
- `LTNHRP8 Percent lit when closed 49- 51 MISS3CH.`
- `LNHRPC8 Lit when closed category 53- 53 $LIT2CAT.`
- `RDLTNF8 Lighting reduced during off hours 55- 55 $YESNO.`
- `BULB8 Incandescent bulbs 57- 57 $YESNO.`
- `FLUOR8 Fluorescent bulbs 59- 59 $YESNO.`
- `CFLR8 Compact fluorescent bulbs 61- 61 $YESNO.`
- `HID8 High intensity discharge (HID) bulbs 63- 63 $YESNO.`
- `HALO8 Halogen bulbs 65- 65 $YESNO.`
- `OTLT8 Other type of bulbs 67- 67 $YESNO.`
- `FLUORP8 Percent lit by fluorescent 69- 71 MISS3CH.`
- `CFLRP8 Percent lit by compact fluorescent 73- 75 MISS3CH.`
- `BULBP8 Percent lit by incandescent 77- 79 MISS3CH.`
- `HALOP8 Percent lit by halogen 81- 83 MISS3CH.`
- `HIDP8 Percent lit by HID 85- 87 MISS3CH.`
- `OTLTP8 Percent lit by other lighting 89- 91 MISS3CH.`
- `SREF8 Specular reflectors 93- 93 $YESNO.`
- `HEB8 Electronic ballasts 95- 95 $YESNO.`
- `EMCSLT8 EMCS controls lighting 97- 97 $YESNO.`
- `WINTYP8 Window glass type 99- 99 $WINDTYP.`

- TINT8 Tinted window glass 101- 101 $YESNO.
- REFL8 Reflective window glass 103- 103 $YESNO.
- AWN8 External overhangs or awnings 105- 105 $YESNO.
- SKYLT8 Skylights/atriums designed for lighting 107- 107 $YESNO.
- AUTOLT8 Auto controls or sensors on lighting 109- 109 $YESNO.
- DAYLTP8 Percent daylight 111- 113 MISS3CH.

2.7.3 Ventilation

CEUS:

Single-zone air handlers:

- System type
- Age
- Hours
- Temp Control
- Optimal start/stop
- Economizer
- Outside Air
- Supply Fan Motor Efficiency
- Supply Airflow Efficiency
- Return Fan Motor Efficiency
- Return Airflow Efficiency

Multi-zone air handlers:

- System type
- Age
- Hours
- Temp Control
- Optimal start/stop
- Economizer type
- Outside Air
- Supply Fan Motor Efficiency
- Supply Airflow Efficiency
- Supply fan control (VAV)
- Return Fan Motor Efficiency
- Return Airflow Efficiency
- Return fan control (VAV)
- Perimeter VAV min ratio
- Interior VAV min ratio

ASHE:

- 8f. Primary type of air handling system

CBECS:

CBECS FILE 3:

- `VAV8 VAV system 184- 184 $YESNO.`
- `ECN8 Economizer cycle 186- 186 $YESNO.`
- `MAINT8 Regular HVAC maintenance 188- 188 $YESNO.`

2.7.4 Cooling

CEUS:

Chilled Water

- Chillers
    - Type
    - Fuel type
    - Heat rejection type
    - Average age
    - Efficiency-full load
    - Efficiency-IPLV
    - Efficiency-COP
    - Chilled water reset
    - VSD compressor
    - Cooling lockout temp
    - Water side economizer
- Chilled water pumps
    - Average age
    - Motor type
    - Motor efficiency
- Heat rejection
    - Type
    - Temp control
    - Condenser water setpoint
    - Average age
    - Fan type
    - Fan control
    - Fan motor efficiency
    - Condenser water pump control
    - Condenser water pump efficiency

For single-zone air handlers:

- Cooling type
- Cooling efficiency:
    - EER
    - SEER

For multi-zone air handlers:

- Cooling Type
- Cooling Efficiency
    - EER

ASHE:

- 8aii. Fuel used for cooling
- 8d. Primary Cooling Source
- 8e. Size of Cooling Source

CBECS:

CBECS FILE 2:

- PLANT8 Central physical plant on complex 129- 129 $YESNO.
- FACDCW8 Plant produces district chilled water 135- 135 $YESNO.
- BLDPLT8 Central plant in building 139- 139 $YESNO.

CBECS FILE 3:

- COOLP8 Percent cooled 111- 113 MISS3CH.
- PKGCL8 Packaged air conditioning units 115- 115 $YESNO.
- RCAC8 Residential-type central A/C 117- 117 $YESNO.
- ACWNWL8 Individual room air conditioners 119- 119 $YESNO.
- HTPMPC8 Heat pumps for cooling 121- 121 $YESNO.
- CHWT8 District chilled water piped in 123- 123 $YESNO.
- CHILLR8 Central chillers inside the building 125- 125 $YESNO.
- EVAPCL8 Evaporative or swamp coolers 127- 127 $YESNO.
- OTCLEQ8 Other cooling equipment 129- 129 $YESNO.
- PKGCP8 Percent cooled by packaged A/C 131- 133 MISS3CH.
- RCACP8 Percent cooled by central A/C 135- 137 MISS3CH.
- ACWNWP8 Percent cooled by individual room A/C 139- 141 MISS3CH.
- HTPCP8 Percent cooled by heat pumps 143- 145 MISS3CH.
- CHWTP8 Percent cooled by district chilled water 147- 149 MISS3CH.
- CHILP8 Percent cooled by central chillers 151- 153 MISS3CH.
- EVAPP8 Percent cooled by swamp coolers 155- 157 MISS3CH.
- OTCLP8 Percent cooled by other cooling equip 159- 161 MISS3CH.
- MAINCL8 Main cooling equipment 163- 164 $CLEQP.
- PKGCPS8 Packaged unit heat pump for cooling 166- 166 $YESNO.
- SPLCPS8 Split system heat pump for cooling 168- 168 $YESNO.
- RMCPS8 Individual room heat pump for cooling 170- 170 $YESNO.
- AIRCPT8 Air source heat pump for cooling 172- 172 $YESNO.
- GRDCPT8 Ground source heat pump for cooling 174- 174 $YESNO.
- WTRCPT8 Water loop heat pump for cooling 176- 176 $YESNO.
- NWMNCL8 Main cooling replaced since 1990 178- 178 $YESNO.
- RDCLNF8 Cooling reduced during 24 hour period 180- 180 $YESNO.
- HWRDCL8 How reduce cooling 182- 182 $HOWRDC.

2.7.5 Space Heating

CEUS:

For single-zone air handlers:

- Heating type
- Heating fuel
- Heating efficiency
    - AFUE
    - Thermal η
    - HSPF
    - COP

For multi-zone air handlers:

- Heating type
- Heating fuel
- Heating efficiency
    - AFUE
    - Thermal η
- Perimeter terminal type
- Perimeter reheat fuel
- Interior terminal type
- Interior terminal fuel

Hot water / steam

- Boiler
    - Type
    - Age
    - Efficiency
    - Space heat lockout temp
    - HW temp reset
- Pumps
    - Average age
    - Motor type
    - Motor efficiency

ASHE:

- 8ai. Fuel used for heating
- 8b. Primary Heating Source
- 8c. Size of Heating System

CBECS:

CBECS FILE 2:

- `PLANT8 Central physical plant on complex 129- 129 $YESNO.`
- `FACDHW8 Plant produces district hot water 133- 133 $YESNO.`
- `BLDPLT8 Central plant in building 139- 139 $YESNO.`

CBECS FILE 3:

- `STUSED8 District steam used 39- 39 $YESNO.`
- `HWUSED8 District hot water used 41- 41 $YESNO.`

- HEATP8 Percent heated 43- 45 MISS3CH.
- HTLS508 Heated to less than 50 degrees 47- 47 $YESNO.
- FURNAC8 Furnaces that heat air directly 49- 49 $YESNO.
- BOILER8 Boilers inside the building 51- 51 $YESNO.
- PKGHT8 Packaged heating units 53- 53 $YESNO.
- SLFCON8 Individual space heaters 55- 55 $YESNO.
- HTPMPH8 Heat pumps for heating 57- 57 $YESNO.
- STHW8 District steam or hot water piped in 59- 59 $YESNO.
- OTHTEQ8 Other heating equipment 61- 61 $YESNO.
- FURNP8 Percent heated by furnace 63- 65 MISS3CH.
- BOILP8 Percent heated by boilers 67- 69 MISS3CH.
- PKGHP8 Percent heated by packaged heating 71- 73 MISS3CH.
- SLFCNP8 Percent heated by indiv space heaters 75- 77 MISS3CH.
- HTPHP8 Percent heated by heat pumps 79- 81 MISS3CH.
- STHWP8 Percent heated by dist steam/hot water 83- 85 MISS3CH.
- OTHTP8 Percent heated by other heating equip 87- 89 MISS3CH.
- MAINHT8 Main heating equipment 91- 91 $HTEQP.
- PKGHPS8 Packaged unit heat pump for heating 93- 93 $YESNO.
- SPLHPS8 Split system heat pump for heating 95- 95 $YESNO.
- RMHPS8 Individual room heat pump for heating 97- 97 $YESNO.
- AIRHPT8 Air source heat pump for heating 99- 99 $YESNO.
- GRDHPT8 Ground source heat pump for heating 101- 101 $YESNO.
- WTRHPT8 Water loop heat pump for heating 103- 103 $YESNO.
- NWMNHT8 Main heating replaced since 1990 105- 105 $YESNO.
- RDHTNF8 Heating reduced during 24 hour period 107- 107 $YESNO.
- HWRDHT8 How reduce heating 109- 109 $HOWRDC.

2.7.5.1 Selected results for heating systems

Heating System Type:

CEUS (CA) hot water / steam boiler types based on 79 sites, 165 data points:

- 62% steam, 38% water (aggregated by Btu)
- 50% steam, 50% water (aggregated by Count)

ASHE primary heating source based on 117 respondents nationwide:

- 70% steam boiler
- 16.5% hot water boiler
- 8.3% “district”
- 0.8% furnace

2.7.6 Domestic Hot Water

CEUS (Service Hot Water / Steam)*

- Type
- Fuel type
- Age
- Efficiency
- Temperature
- Tank insulation
- Pipe insulation
- Recirculation pump type

* These categories are not active in demonstration version of EnergyIQ.

ASHE:

- 8aiii. Fuel used for water heating (not specified if heating water or DHW)
- 8h. Primary Domestic Heating System

CBECS:

CBECS FILE 2:

- `PLANT8 Central physical plant on complex 129- 129 $YESNO.`
- `FACDST8 Plant produces district steam 131- 131 $YESNO.`
- `FACDHW8 Plant produces district hot water 133- 133 $YESNO.`
- `BLDPLT8 Central plant in building 139- 139 $YESNO.`

CBECS FILE 4:

- `HWUSED8 District hot water used 41- 41 $YESNO.`
- `WTHTEQ8 Water heating equipment 43- 43 $WATREQP.`
- `INSTWT8 Instant hot water 45- 45 $YESNO.`
- `HWTRM8 Large amounts of hot water used 61- 61 $YESNO.`
- `LAUNDR8 Laundry onsite 63- 63 $LAUND.`
- `HTPOOL8 Heated indoor pool 73- 73 $YESNO.`
- `PLSRC8 Energy source used to heat pool 75- 75 $POOLSRC.`

2.7.6.1 Selected results for domestic hot water

DHW System Type:

ASHE primary domestic water heating system:

- 62% centralized
- 14% distributed
- 20% combination

2.7.7 Electrical Plug & Process Loads

CEUS: Plug & Process Loads*

- Office equip intensity
- Food service equip intensity
- Refrigeration intensity

* These categories are not active in demonstration version of EnergyIQ.

ASHE: No questions of specific relevance to this category.

CBECS:

CBECS FILE 4:

- RFGEQP8 Refrigeration equipment used 77- 77 $YESNO.
- RFGWI8 Walk-in refrigeration units 79- 79 $YESNO.
- RFGOP8 Open case refrigeration units 81- 81 $YESNO.
- RFGCL8 Closed case refrigeration units 83- 83 $YESNO.
- RFGRES8 Residential-type refrigerators 85- 85 $YESNO.
- RFGVEN8 Refrigerated vending machines 87- 87 $YESNO.
- RFGWIN8 Number of walk-in refrigeration units 89- 92 MISS4CH.
- RFGOPN8 Number of open refrigerated cases 94- 97 MISS4CH.
- RFGRSN8 Number of residential refrigerators 99- 102 MISS4CH.
- RFGCLN8 Number of closed refrigerated cases 104- 107 MISS4CH.
- RFGVNN8 Number of vending machines 109- 112 MISS4CH.
- PCTERM8 Computers used 114- 114 $YESNO.
- SERVER8 Dedicated servers used 116- 116 $YESNO.
- MNFRM8 Mainframe computer room 118- 118 $YESNO.
- SRVFRM8 Server farm 120- 120 $YESNO.
- TRNGRM8 Computer-based training room 122- 122 $YESNO.
- STDNRM8 Student or public computer center 124- 124 $YESNO.
- OTPCRM8 Other computer area 126- 126 $YESNO.
- PCRMP8 Computer area percent 128- 130 MISS3CH.
- SRVNUM8 Number of servers 132- 139 MISS8CH.
- SRVRC8 Number of servers category 141- 142 $PCCAT.
- PCNUM8 Number of computers 144- 151 MISS8CH.
- PCTRMC8 Number of computers category 153- 154 $PCCAT.
- FLAT8 Flat screen monitors 156- 156 $YESNO.
- FLATC8 Flat screen monitors category 158- 158 $FLAT.
- PRNTRN8 Number of printers 160- 167 MISS8CH.
- PRNTYP8 Type of printers 169- 169 $PRNTR.
- COPIER8 Photocopiers 177- 177 $YESNO.
- COPRN8 Number of photocopiers 179- 183 MISS5CH.

- FAX8 FAX machines 185- 185 $YESNO.
- RDOFEQ8 Equipment turned off during off hours 187- 187 $EQPOFF.

3 Organizations and Programs

There are many organizations that provide resources or information relevant to energy use in healthcare facilities. These resources include regulatory requirements and industry standard design guidance as well as energy and sustainability best practices for design and operations. The organizations include regulatory agencies, professional societies and networks of institutions and other organizations. In the section below, we present short descriptions of some key groups and organizations. Specific resources related to energy are identified.

3.1 Industry Associations

3.1.1 American Hospital Association (AHA)

The following description is provided on the AHA web site (aha.org):

> The American Hospital Association (AHA) is the national organization that represents and serves all types of hospitals, health care networks, and their patients and communities. Close to 5,000 hospitals, health care systems, networks, other providers of care and 37,000 individual members come together to form the AHA.
>
> Through our representation and advocacy activities, AHA ensures that members' perspectives and needs are heard and addressed in national health policy development, legislative and regulatory debates, and judicial matters. Our advocacy efforts include the legislative and executive branches and include the legislative and regulatory arenas.
>
> Founded in 1898, the AHA provides education for health care leaders and is a source of information on health care issues and trends

The AHA publishes an annual compilation of information about conditions and trends in the U.S. hospital industry, including information about the hospital market, workforce, financing, etc. This "Trendwatch Chartbook" is available for public viewing on the AHA site[29]. The "Hospital Statistics" series (Health Forum LLC, 2008) is another annual compilation of information.

3.2 Professional Societies

The following organizations provide support, networking, training, and certifications for architects and engineers involved in building design and operations. Activities include the setting of design and operations standards for healthcare (and other) buildings.

3.2.1 American College of Healthcare Executives (ACHE)

The organization's web site (ache.org) describes ACHE as "an international professional society of more than 30,000 healthcare executives who lead hospitals, healthcare systems and other healthcare organizations." ACHE offers credentialing and educational programs, an annual Congress on Healthcare Leadership, and a network of local chapters that facilitate networking and provide education and career development. ACHE publishes Healthcare Executive

[29] http://www.aha.org/aha/research-and-trends/chartbook/index.html

magazine, two journals (*Journal of Healthcare Management* and *Frontiers of Health Services Management*), books, textbooks for college courses and other groundbreaking research through the Health Administration Press.

3.2.2 American Institute of Architects (AIA)

The AIA (aia.org) publishes the *Guidelines for Design and Construction of Health Care Facilities*, commonly referred to as the AIA Guidelines[30], on a four-to-five year revision cycle. This guidance document is referenced by many federal and state jurisdictions. While it was originally created to provide minimum construction standards for hospitals, it has evolved to include engineering systems, infection control, and safety as well as architectural guidelines for design and construction of hospitals, outpatient facilities, and other types of health care facilities. The Guidelines are intended for use during new construction. The Facility Guidelines Institute (fgiguidance.org) oversees the revision process and the work of the Health Guidelines Revision Committee.

3.2.3 American Society for Healthcare Engineering (ASHE)

According to its web site (ashe.org), ASHE is a professional society that is "dedicated to optimizing the healthcare physical environment" (mission statement), with a vision to "engage stakeholders in the creation of the optimum healing healthcare environment." ASHE has the following content advisory committees:

- Facilities Management
- Planning, Design & Construction Management
- Safety, Security, Emergency Preparedness & Disaster Recovery
- Technologies/Clinical Engineering

The ASHE web-site provides a list of relevant codes and standards with brief descriptions and active links. Included are all of the guides noted above and others.

As described above, ASHE publishes the Healthcare Energy Guidebook which is based on a nationwide survey of hospital facility managers and includes information about the facilities, engineered systems, practices and EPA Energy Star scores. The Green Building Committee of ASHE created the Green Healthcare Construction Guidance Statement (Developed in January 2002, revised October 2004) for use in conjunction with the ASHE Sustainable Design Awards Program.

3.2.4 American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE)

The mission of ASHRAE (ashrae.org) is "to advance the arts and sciences of heating, ventilating, air conditioning and refrigerating to serve humanity and promote a sustainable world." ASHRAE publishes or co-publishes an array of standards of broad relevance to building ventilation and energy use including the following:

- Standard 55-2004: Thermal Environmental Conditions for Human Occupancy, published in cooperation with the American National Standards Institute (ANSI), "specifies conditions in which a specified fraction of the occupants will find the environment thermally acceptable."

[30] http://www.aia.org/aah_gd_hospcons

- Standard 62-2001: Ventilation for Acceptable Indoor Air Quality, published in cooperation with the American National Standards Institute (ANSI), sets minimum ventilation rates and other requirements for commercial and institutional buildings.
- Standard 90.1-(YEAR): Energy Standard for Buildings Except Low-Rise Residential Buildings, published in cooperation with ANSI and IESNA provides the minimum requirements for the design of energy efficient buildings.

Of special relevance to the health care industry is ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation Standards for Healthcare Facilities.

ASHRAE also co-publishes advanced energy design guides (AEDG), which are currently available for K-12 schools, small retail, small warehouses and self-storage, and small office buildings[31]. AEDGs for small hospitals is nearing completion[32] and work has begun on an AEDG for large hospitals.

The technical work of ASHRAE is organized through technical committees (TCs) and accomplished by the voluntary service of its members; TC9.6 focuses on healthcare buildings[33].

3.2.5 California Society for Healthcare Engineering (CSHE)

The CSHE (cshe.org) is the California affiliate to ASHE, with a stated mission "to serve as a resource for the personal and professional development of members, so that they are the best in the health care environment and qualified to address the unique needs of health care organizations."

3.2.6 IEEE

The following description is extracted from the IEEE web site (ieee.org):
"A non-profit organization, IEEE is the world's leading professional association for the advancement of technology. The IEEE name was originally an acronym for the Institute of Electrical and Electronics Engineers, Inc. Today, the organization's scope of interest has expanded into so many related fields, that it is simply referred to by the letters I-E-E-E (pronounced Eye-triple-E)."

IEEE publishes a design guide (IEEE, 2007) for electrical systems in health care facilities[34].

3.2.7 Illuminating Engineering Society of North America (IESNA)

The mission of IESNA (iesna.org) is "to improve the lighted environment by bringing together those with lighting knowledge and by translating that knowledge into actions that benefit the public." IESNA is a co-publisher of Standard 90.1 (Building Energy) and provides guidance on illumination levels for many specific areas of hospitals and other health care facilities (IESNA, 2000).

3.2.8 International Facility Management Association (IFMA)

---

[31] Available as free download as of 11/26/08: http://www.ashrae.org/publications/page/1604. If this link no longer active, search ASHRAE publications page.

[32] The effort is being led by Shanti Plesss of the Natioanl Renewable Energy Lab, Golden, CO and Walt Vernon of Mazzetti and Associates, San Francisco, CA.

[33] http://tc96.ashraetcs.org/

[34] http://ieeexplore.ieee.org/servlet/opac?punumber=4299430; DOI: 10.1109/IEEESTD.2007.4299432

The society's web site (ifma.org) describes IFMA as "the world's largest and most widely recognized international association for professional facility managers, supporting more than 19,000 members in 60 countries. The association's members, represented in 125 chapters and 15 councils worldwide, manage more than 37 billion square feet of property and annually purchase more than $100 billion in products and services. Formed in 1980, IFMA certifies facility managers, conducts research, provides educational programs, recognizes facility management degree and certificate programs and produces World Workplace, the world's largest facility management conference and exposition." The IFMA publishes the bi-monthly Facility Management Journal. In 2008, the organization developed and offered a half-day seminar series on "High Performance Hospitals & Medical Research Facilities" that included energy efficiency.

The IFMA conducts and contributes to research about facility management including practices and plans that may impact energy use and opinions about energy costs and the potential benefits of energy saving measures and upgrades; summary results of past studies are posted on the IFMA web site[35]. Of broad relevance to energy are the following surveys: sustainability surveys conducted in 2002, 2005, and 2008; a 2002 energy awareness study; and energy efficiency studies in 2007 and 2008. The posted results for most of these studies do not break out results for health care or any other sector. However, the 2007 energy efficiency study[36] does present results by sector, including health care; highlights from this study are presented and discussed in a subsequent section.

3.3 Regulatory Organizations

3.3.1 California Office of Statewide Health Planning and Development (OSHPD)

OHSPD (oshpd.ca.gov) is the agency responsible for approving designs for new construction and retrofits of California acute care hospitals and psychiatric hospitals, skilled nursing facilities, intermediate care facilities, outpatient clinics and correctional treatment facilities. OSHPD additionally "administers programs which endeavor to implement the vision of "Equitable Healthcare Accessibility for California." The Healthcare Information Division collects and maintains data about healthcare facilities and delivery, including hospital discharges.

3.3.2 Federal Regulatory Agencies

A number of U.S. federal agencies have roles in regulating healthcare facilities and setting standards. These include the Department of Health and Human Services (DHSS) and the Occupational Safety and Health Administration (OSHA. The Centers for Disease Control (CDC), which helps produce the Guidelines for Environmental Infection Control in Health-Care Facilities is within the DHHS.

3.3.2.1 Joint Commission on Accreditation of Healthcare Organizations

The Joint Commission (jointcommission.org) is an independent, not-for-profit body that accredits and certifies U.S. health care organizations and programs. The Joint Commission uses the AIA Guidelines as their standards for indoor air quality and ventilation.

[35] http://www.ifma.org/tools/research/survey_results.cfm
[36] http://www.ifma.org/tools/research/surveys/energy_efficiency_indicator.pdf

3.4 Health Care Sustainability Groups

3.4.1 Global Health and Safety Initiative (GHSI)

The GHSI (globalhealthandsafety.org) describes itself as "a sector-wide collaboration to transform the way that healthcare designs, builds and operates its facilities as well as the products healthcare uses within those facilities. GHSI aims to build a learning community and leverage the expertise of its partners to support evidence-based improvements at the intersection of patient safety, worker safety and environmental sustainability." GHSI is working with Health Care Without Harm, Practice Greenhealth, the Center for Health Design, and eighteen founding healthcare systems to develop action plans in the following programmatic areas: Purchasing, Built Environment, Operations, Public Policy/Corporate Social Responsibility and Research. The Built Environment working group web-site[37] provides summaries and links to best practice guides for energy and other environmental issues. Their planned "Energy Efficient, High Performance Hospitals Toolkit" will include the Practice Greenhealth Clean Energy Exchange and the ASHRAE Advanced Energy Design Guide.

3.4.2 Practice Greenhealth

Practice Greenhealth (practicegreenhealth.org) is "the nation's leading membership and networking organization for institutions in the healthcare community that have made a commitment to sustainable, eco-friendly practices. Members include hospitals, healthcare systems, businesses and other stakeholders engaged in the greening of healthcare to improve the health of patients, staff and the environment."

Practice Greenhealth offers information, best practices, and solutions in the following areas[38]:

- Operations / facilities management.
- Design & Construction (through the Green Guide for Health Care, gghc.org).
- Clean Energy
- Environmental Purchasing
- Regulations & Standards

The organization offers the following tools, educational opportunities, and services[39] aimed at greening the healthcare industry:

- Webinars
- Healthcare Clean Energy Exchange
- Education & Consulting Services
- Training for Sustainability Professionals
- Environmental Data Tracking Tool
- Practice Greenhealth Forums
- Listserv

3.4.3 Health Care Without Harm

[37] http://www.globalhealthandsafety.org/workgroups/environment/
[38] http://www.practicegreenhealth.org/educate
[39] http://www.practicegreenhealth.org/tools

Health Care Without Harm (noharm.org) is "an international coalition of hospitals and health care systems, medical professionals, community groups, health-affected constituencies, labor unions, environmental and environmental health organizations and religious groups" with a mission to "transform the health care sector worldwide, without compromising patient safety or care, so that it is ecologically sustainable and no longer a source of harm to public health and the environment." The organization's agenda covers a broad collection of sustainable issues, including "environmental impacts" of the construction and operations of health care facilities.

3.4.4 The Center for Health Design

The Center for Health Design (healthdesign.org) describes itself as a "research and advocacy organization of forward-thinking healthcare and design professionals who are leading the quest to improve the quality of healthcare through building architecture and design." Their mission is to "transform healthcare settings - including hospitals, clinics, physician offices, and nursing homes - into healing environments that contribute to health and improve outcomes through the creative use of evidence-based design." Evidence-based design bases decisions about the built environment on "credible research to achieve the best possible outcomes." The organization hosts an annual conference and the web site offers publications and other resources to promote these design principles. These resources are influential in the community of health care facility designers.

3.5 Government Programs

3.5.1 "EnergySmart" Hospitals and Hospital Energy Alliance (DOE)

The U.S. Department of Energy runs two related programs that promote energy efficiency in the healthcare industry. The EnergySmart Hospitals[40] program focuses on helping U.S. hospitals achieve cost and energy savings through application of efficient and renewable energy technology in both new and existing facilities. The program website offers information and guidance on energy efficiency opportunities in new construction and retrofits and operations. The following are the stated goals of the program:

- Promote 20% improved efficiency in existing buildings and 30% in new construction over current standards
- Increase efficient and renewable energy applications in hospitals
- Reduce energy use and operating costs
- Create healthier healing and work environments
- Maximize successful hospital upgrades and design strategies
- Ensure reliable backup power during disasters
- Improve environmental performance

The Hospital Energy Alliance[41], which launched in late April 2009, organizes the efforts of hospitals and national associations to promote information on successful strategies for energy efficiency technology and process integration, and to coordinate demand for highly-efficient products and services.

[40] http://www1.eere.energy.gov/buildings/energysmarthospitals/
[41] http://www1.eere.energy.gov/buildings/hospital/

3.6 Energy Efficiency Programs Targeting Healthcare Facilities

Provided below are summary descriptions of two regional energy efficiency initiatives.

The Pacific Gas & Electric Company (PG&E) operates a portfolio of residential and commercial energy efficiency programs that draw funding from public service charges approved by the California Public Utilities Commission. PG&E specifically targets and applies their commercial programs to the health care sector[42]

The Northwest Energy Efficiency Alliance (NEEA, nwalliance.org) promotes energy efficiency in new and existing hospitals through their "BetterBricks" activities[43]; these include tools training and support for decision makers to integrate energy management with business goals including improved quality and reduced costs. The program targets hospital executives and facility managers to help make the business case for energy upgrades. The program additionally provides direct assistance to hospitals for strategic energy planning, changing of energy-related business practices and application of best practices for energy. A report on program activities and successes is available online[44].

4 Design and Best Practice Guides

This section lists publicly-available guides on design and operations of healthcare facilities. Also listed are collections of case-study reports.

4.1 General Healthcare Design Guides

4.1.1 Building Type Basics for Healthcare Facilities (Kobus et al., 2008)

This book provides guidance that is primarily focused on the efficient provision of healthcare services; little attention is paid to energy use and energy efficiency.

4.1.2 Guidelines for Design and Construction of Health Care Facilities (AIA, 2006)

This is the industry-standard guidance document for the design of health care facilities; published by the American Institute of Architects.

4.1.3 HVAC Design Manual for New Hospitals, Replacement Hospitals, Ambulatory Care, Clinical Additions, Energy Centers, Outpatient Clinics, Animal Research Facilities, Laboratory Buildings (VA, 2008)

This manual provides guidance on design requirement for facilities of the U.S. Department of Veterans Affairs. The manual was updated to incorporate changes due to several federal laws and executive orders including EPACT 2005 and Executive Order No. 13423 (2007), both of which focus on energy.

4.1.4 Whole Building Design Guide: Health Care Facilities (Carr, 2008)

The WBDG web site (www.wbdg.org) describes itself as follows:

> The WBDG is the only web-based portal providing government and industry practitioners with one-stop access to up-to-date information on a wide range of building-

[42] http://pge.com/mybusiness/energysavingsrebates/incentivesbyindustry/healthcarebio/
[43] http://www.nwalliance.org/ourwork/projectsummary.aspx?ID=90
[44] http://www.nwalliance.org/research/reports/E08-188.pdf

related guidance, criteria and technology from a 'whole buildings' perspective. Currently organized into three major categories—Design Guidance, Project Management and Operations & Maintenance—at the heart of the WBDG are Resource Pages, reductive summaries on particular topics.

Development of the WBDG is a collaborative effort among federal agencies, private sector companies, non-profit organizations and educational institutions. Its success depends on industry and government experts contributing their knowledge and experience to better serve the building community.

The WBDG web site is offered as an assistance to the building community by the National Institute of Building Sciences (NIBS) through funding support from the Department of Defense, the NAVFAC Engineering Innovation and Criteria Office, the Army Corps of Engineers, the U.S. Air Force, the U.S. General Services Administration (GSA), the Department of Veterans Affairs, the National Aeronautics and Space Administration (NASA), and the Department of Energy, and the assistance of the Sustainable Buildings Industry Council (SBIC). A Board of Direction and Advisory Committee, consisting of representatives from over 25 participating federal agencies guide the development of the WBDG.

The site includes design guidance and a list of design resources specific to health care facilities[45], in addition to resources and guidance (e.g. for operations & maintenance) that are relevant to commercial buildings in general.

4.1.5 Guidelines for Environmental Infection Control in Health-Care Facilities

This document (Sehulster et al., 2004) provides guidelines for infection control that include ventilation and filtration systems to address both immune-compromised and patients with diseases that are communicable through air (along with other measures addressing water, surfaces, etc.). These guidelines pertain to rooms and areas housing the patients described above. The air treatment guidelines currently are satisfied through use of high pressure drop (energy intensive) filtration.

4.2 Sustainable Healthcare Facility Design and Operations Guides

4.2.1 ASHE Healthcare Energy Guidebook (ASHE, 2004)

In an effort to understand the determinants of energy efficient (and inefficient) facilities, ASHE conducted a survey of facility operators and examined correlations between the survey responses and facility Energy Star ratings. Specifically, facility characteristics and practices were compared for facilities with Energy Star ratings in the top and bottom quartiles. The rationale was that significant differences would identify energy efficiency best practices. The report includes a preventive maintenance checklist organized by equipment and provides complete responses to more open-ended questions about energy retrofit decisions and other qualitative questions.

4.2.2 Green Guide for Health Care

[45] http://www.wbdg.org/design/health_care.php

The Green Guide for Health Care (gghc.org) is "a self-certifying, best practices toolkit" that addresses sustainable building design, construction, and operations of healthcare facilities. The Green Guide assigns points for practices determined to contribute to sustainability in several categories including energy. While the focus is on construction, existing facilities can track their performance with the *Operations* section. Newly constructed or renovated facilities are encouraged to target operations-related credits and establish these commitments as policy. The Green Guide was developed in advance of LEED for Healthcare and, by agreement, uses a similar structure and credit numbering scheme. Version 2.0 of the Green Guide was launched in 2004 with a two-year pilot program that encompassed 115 projects and generated feedback that lead to revisions and improvements for Versions 2.1 (2005) and 2.2 (2007). The Green Guide is customized for health care facilities with institutional occupancies (e.g. acute care hospitals, nursing homes), but other facility types (medical offices, outpatient clinics) can be evaluated with the same tools.

4.2.3 Greener Hospitals: Improving Environmental Performance

This paper was produced by the Environment Science Center of the Wissenschaftszentrum Umwelt University (WUU), Augsburg, Germany with support from Bristol-Myers Squibb Company. The genesis of the document is unclear, but the Forward, written by Dr. Armin Reller of WUU, describes it as a "manual" that "provides practical advice to help healthcare facilities improve their environmental management systems and performance." The manual features sections that describe and provide guidance on implementing environmental management systems, and sub-sections on specific areas of environmental concern including energy management (Section 5.3). Section 6 is an "environmental checklist for healthcare facilities". Paper copies of the manual are is available from Bristol-Myers Squibb Company[46].

4.2.4 LEED for Healthcare, U.S. Green Building Council (USGBC)

The U.S. Green Building Council (usgbc.org) is a non-profit organization with membership from across the building industry that has the mission to "transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life." They developed and manage the LEED (Leadership in Energy and Environmental Design) rating system as a means to assess buildings in the areas of sustainable site development, water savings, energy efficiency, materials and resources selection, and indoor environmental quality. The USGBC describes LEED as "a practical rating tool for green building design and construction that provides immediate and measurable results for building owners and occupants." LEED is offered for various building types including health care.

The LEED for Healthcare Green Building Rating System[47] was designed for inpatient care facilities, licensed outpatient care facilities, and licensed long term care facilities, but may also be applied to medical offices, assisted living facilities and medical education & research centers. The website notes that "LEED for Healthcare addresses issues such as increased sensitivity to chemicals and pollutants, traveling distances from parking facilities, and access to natural spaces." The LEED for Healthcare rating system was developed in collaboration with the

[46] Contact phone number: 315-432-2997; contact person as of 05-Dec-2008 is Chris Repe (chris.repe@bms.com)
[47] http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1765

Green Guide for Healthcare through an alignment with the GGHC new construction (self-assessment) rating scheme and a GGHC pilot program at more than 100 health care facilities.

4.2.5 A Prescriptive Path to Energy Efficiency Improvements in Hospitals (Houghton and Guttmann, 2007)

This document describes a prescribed package of energy efficiency measures that can be used to meet the requirements of the *Green Guide for Health Care's* (GGHC) Optimize Energy Performance credits. The package was developed through a process that included building energy modeling (with DOE-2.1E), evaluation of measures for cost effectiveness, climate neutrality, and confidence of energy performance. The following energy efficiency measures (limited to hospitals of 70,000 square feet or more) are included:

- Lighting Power Density 10% less than ASHRAE 90.1-2004
- High Performance Windows and Glazing (Uwindow = 0.40; SHGCcog = 0.38)
- Occupancy Sensor Lighting Controls for all applicable areas (including Offices and Storage Areas)
- Central VAV AHUs using Chilled and Heating Hot Water
- Fan power reduced 10% less than limit under ASHRAE 90.1-2004 Appendix G
- Turn-Down Ratio of 30% on VAV Boxes
- Exterior Lighting Power 20% less than ASHRAE 90.1-2004
- High Efficiency Boiler Plant (90% thermal operating efficiency)
- Turn-down Ratio of 30% for Heating Hot Water and Chilled Water Pumps variable speed drives
- High Efficiency Variable Speed Chillers (0.52 kW/ton at Full Load, and 0.40 kW/ton IPLV)
- Premium Efficiency Motors for Fans and Pumps

The document further recommends that projects comply with the prescriptive measures of the 2007 New Buildings Institute *Advanced Buildings Core Performance Guide* with some modifications.

4.2.6 ASHRAE Standard 189.1

As described in a May 4 press release by ASHRAE "Proposed Standard 189.1, *Standard for the Design of High Performance, Green Buildings Except Low-Rise Residential Buildings*, is being developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers in conjunction with the Illuminating Engineering Society of North America (IESNA) and the U.S. Green Building Council (USGBC). This is the first such green building standard in the United States."

4.2.7 Sustainable Healthcare Architecture (Guenther and Vittori, 2008)

From the product description on Amazon.com:

> Written by leading national experts on the subject -- one of whom was recognized by Time magazine as a green innovator -- Sustainable Healthcare Architecture is the key guide to designing sustainable healthcare facilities. Building on the authors combined knowledge and experience, this book includes case studies of more than 50 of the best contemporary sustainable healthcare projects. The book also contains numerous essays contributed by other leaders in sustainable design and healthcare. Additionally, the

authors provide background information on LEED for Healthcare, as well as on the Green Guide for Health Care, which they were instrumental in developing.

4.2.8 Advanced Energy Design Guides (AEDG)

Advanced energy design guides are being prepared for small hospitals and large hospitals; as they are completed, they will be posted on the ASHRAE website for public access.[48]

4.2.9 California Green Building Code

Part 11 of the California Building Code (Title 24) specifies requirements for Green Building Standards. Requirements vary by building type and are set by the California Building Standards Commission based on recommendations of state agencies with responsibility for each building type. Requirements for healthcare buildings (acute care and psychiatric hospitals, skilled nursing facilities, intermediate care facilities, outpatient clinics and correctional treatment facilities) are based on recommendations by OSHPD. Chapter 5 of this code covers energy efficiency. The (initial) 2008[49] code included only voluntary measures. OSHPD is currently developing recommendations for the 2010 code which is expected to include some mandatory provisions. The new code should be accessible via the Title 24 web site.[50]

4.2.10 Specifications for Performance Monitoring Systems (Gillespie et al., 2007)

This document[51] provides guidance and specification for the selection, installation and programming of equipment to monitor energy use and system performance in commercial buildings. The guide is not targeted to hospitals. It is mentioned here in recognition of the value of energy monitoring and the interest of many in the health care sector of guidance on how to set up an energy monitoring system.

5 Other Information

Green Healthcare Institutions: Health, Environment, and Economics. Workshop Summary (Frumkin and Coussens, 2007)

[48] http://www.ashrae.org/publications/page/1604
[49] http://www.documents.dgs.ca.gov/bsc/2009/part11_2008_calgreen_code.pdf
[50] http://www.bsc.ca.gov/title_24/default.htm
[51] http://cbs.lbl.gov/performance-monitoring/specifications/

6 References

AIA, 2006. 2006 Guidelines for Design & Construction of Health Care Facilities. American Institute of Architects, Washington, DC.

ASHE, 2004. Healthcare Energy Guidebook: Results of the Healthcare Energy Project, November 2001 through December 2003, American Society for Healthcare Engineering, Chicago, IL.

Carr, R.F., 2008. Whole Building Design Guide: Health Care Facilities. National Institute of Building Services, Washington, DC, 28-Oct-2008, pp.

Cramer-Krasselt, 2007. Energy Efficiency Indicator Survey, Johnson Controls and International Facility Managers Association, April 18, 2007. http://www.ifma.org/tools/research/survey_results.cfm

Deru, M. and Torcellini, P., 2006. Source energy and emission factors for energy use in buildings. Technical Report NREL/TP-550-38617, National Renewable Energy Laboratory, Golden, CO, June 2006. Available at http://www.osti.gov/bridge

EPA, 2001. ENERGY STAR® Performance Ratings: Technical Methodology for Hospital (Acute Care/Children's), Environmental Protection Agency, November 2001. http://www.energystar.gov/ia/business/evaluate_performance/hospital_tech_desc.pdf

EPA, 2004. ENERGY STAR® Performance Ratings: Technical Methodology for Medical Office Building, Environmental Protection Agency, February 2004. http://www.energystar.gov/ia/business/evaluate_performance/hospital_tech_desc.pdf

EPA, 2007. ENERGY STAR Performance Ratings: Methodology for Incorporating Source Energy Use, U.S. Environmental Protection Agency. http://www.energystar.gov/ia/business/evaluate_performance/site_source.pdf

Frumkin, H. and Coussens, C., 2007. Green Healthcare Institutions: Health, Environment, and Economics. Workshop Summary., Washington, DCThe National Academies Press.

Gillespie, K.L., Haves, P., Hitchcock, R.J., Deringer, J.J. and Kinney, K., 2007. A Specifications Guide for Performance Monitoring Systems, Lawrence Berkeley National Laboratory (Berkeley, CA), Pacific Gas and Electric Company (San Ramon, CA), Deringer Group (Berkeley, CA), QuEST (Berkeley, CA), March 23, 2007. http://cbs.lbl.gov/performance-monitoring/specifications/

Guenther, R. and Vittori, G., 2008. Sustainable Healthcare Architecture. John Wiley & Sons, Hoboken, NJ, 448 pp.

Health Forum LLC, 2008. AHA Hospital Statistics. Health Forum LLC, American Hospital Association, Chicago, IL.

Houghton, A. and Guttmann, S., 2007. A prescriptive path to energy efficiency improvements for hospitals, Submitted by The Green Guide for Health Care, c/o Center for Maximum Potential Building Systems, Austin, TX, December 19, 2007.

IEEE, 2007. IEEE Recommended Practice for Electric Systems in Health Care Facilities. 602-2007 (White Book), August, 2007.

IESNA, 2000. The IESNA Lighting Handbook: Reference and Applications. Illuminating Society of North America, New York, NY.

Kobus, R.L., Skaggs, R.L., Bobrow, M., Thomas, J., Payette, T.M. and Chin, S.P., 2008. Building type basics for healthcare facilities. John Wiley & Sons.

Reed, J.H., Johnson, K., Riggert, J. and Oh, J.D., 2004. Who Plays and Who Decides. U.S, Department of Energy, Office of Building Technology, State and Community Programs; contract number DE-AF26-02NT20528., Innovologie LLC, Rockville, MD.

Sehulster, L.M. et al., 2004. Recommendations from CDC and the Healthcare Infection Control Practices Adviosry Committee (HICPAC), American Society for Healthcare Engineering / American Hospital Association, Chicago, IL. www.cdc.gov/ncidod/hip/enviro/guide.htm

VA, 2008. HVAC Design Manual for: New Hospitals, Replacement Hospitals, Ambulatory Care, Clinical Additions, Energy Centers, Outpatient Clinics, Animal Research Facilities, Laboratory Buildings. Facilities Quality Service (00CFM1A), Office of Construction & Facilities Management, Department of Veterans Affairs, Washington DC.