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HPCBS

High Performance Commercial Building Systems

California Commercial Building Energy Benchmarking Final Project Report

Element 2. Life-Cycle Tools
Project 2.1 - Benchmarking and Performance Metrics
Task 2.1.1 - Final benchmarking tool and report evaluating benchmarking with advanced normalization procedures

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1. Introduction

Building energy benchmarking is the comparison of whole-building energy use relative to a set of similar buildings. It provides a useful starting point for individual energy audits and for targeting buildings for energy-saving measures in multiple-site audits. Benchmarking is of interest and practical use to a number of groups. Energy service companies and performance contractors communicate energy savings potential with "typical" and "best-practice" benchmarks while control companies and utilities can provide direct tracking of energy use and combine data from multiple buildings. Benchmarking is also useful in the design stage of a new building or retrofit to determine if a design is relatively efficient. Energy managers and building owners have an ongoing interest in comparing energy performance to others. Large corporations, schools, and government agencies with numerous facilities also use benchmarking methods to compare their buildings to each other.

The primary goal of Task 2.1.1 Web-based Benchmarking was the development of a web-based benchmarking tool, dubbed Cal-Arch, for benchmarking energy use in California commercial buildings. While there were several other benchmarking tools available to California consumers prior to the development of Cal-Arch, there were none that were based solely on California data. Most available benchmarking information, including the Energy Star performance rating, were developed using DOE's Commercial Building Energy Consumption Survey (CBECS), which does not provide state-level data. Each database and tool has advantages as well as limitations, such as the number of buildings and the coverage by type, climate regions and end uses.

There is considerable commercial interest in benchmarking because it provides an inexpensive method of screening buildings for tune-ups and retrofits. However, private companies who collect and manage consumption data are concerned that the identities of building owners might be revealed and hence are reluctant to share their data. The California Commercial End Use Survey (CEUS), the primary source of data for Cal-Arch, is a unique source of information on commercial buildings in California. It has not been made public; however, it was made available by CEC to LBNL for the purpose of developing a public benchmarking tool.

The remainder of this report is organized as follows:

Section 2. Approach. Discusses the technical and outreach activities undertaken in the web-based benchmarking project.

Section 3. Outcomes. Describes the project results, including the current implementation of Cal-Arch.

Section 4. Conclusions and Recommendations. Discusses what has been learned during this project and plans and recommendations for future action.

Additional information is included in the appendices.

2. Approach

This section describes the technical and outreach activities in the web-based benchmarking project. First and foremost is the development of Cal-Arch. Additional technical activities include the development of a specification for Cal-Arch, the evaluation of related benchmarking methodologies, and analysis of CEUS. Outreach activities include collaborations, workshops, and conference presentations.

2.1. TECHICAL ACTIVITIES

The main technical activities were the analysis of the CEUS database and the development of the Cal-Arch program and website, as well as evaluation of benchmarking methodology.

2.1.1 CEUS Data Analysis

In the initial phase of the project involved obtaining CEUS in SAS data sets from the CEC and performing extensive exploratory analysis of the database. The data were analyzed and converted to the format required for the benchmarking tool. The data used were utility and fuels information, floor area, building type, and zip code/climate zone. A memo describing the processing of data was reviewed by the California Energy Commission (1).

Statistical Weights

The initial conditions of use of CEUS required that statistical weights included in the survey be used, and thus the initial version of the software released used these weights. Both energy and premise weights were supplied. After reviewing the distributions with and without weights, and after much consideration of the suitability of the weights for this application, CEC agreed that the weights were not necessary for the purpose of masking site information.

The reason for having statistical weights in the first place is to extrapolate the sample to the population. Thus, for the PG&E CEUS, the weighted total energy use of the sample would represent the total energy use of the population represented by the sample. The decision was made not to use the weights because there was not evidence that they were valid or necessary our application. First, the weights were developed separately for PG&E CEUS and SCE CEUS, and were developed according to different criteria, sampling stratifications, and for different populations. Hence, when combining information from different surveys it was not clear what the weights represented or if there was any validity for using them in the context of Cal-Arch. Furthermore, they were confusing to users and prevented the inclusion of data from other sources without statistical weights, such as the Non-Residential New Construction Survey (NRNC), Energy Star Buildings Database, and independent datasets such as provided by GSA.

The EUI distributions change greatly when the weights are used. Figure 2.1 below shows the weighted and unweighted distributions for whole-building energy use in offices.

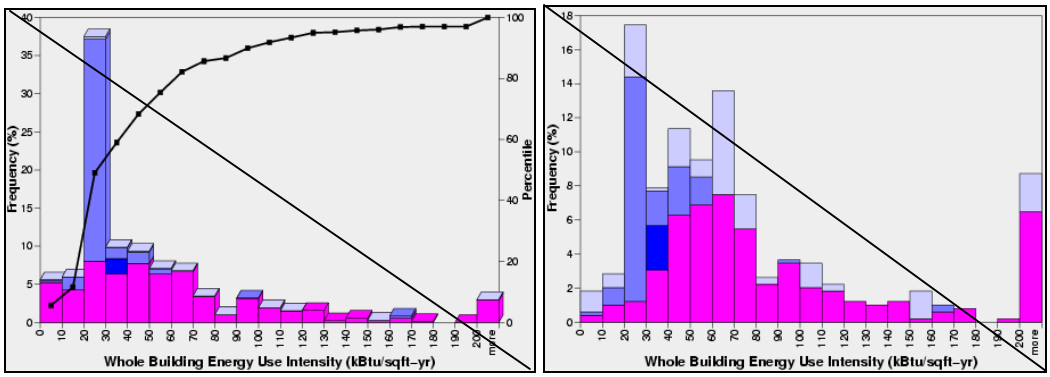

Figure 2.1. Office EUI distribution, weighted and unweighted

2.2.1 Software Development

The Cal-Arch program is based on the existing Arch for U.S. buildings. Arch was duplicated and then modified to create Cal-Arch. Improvements were made to the graphic generation component to increase the speed of the program and functionality modified to meet the specifications of Cal-Arch.

Initial changes included the replacement of the census region parameter with California climate zone and the implementation of statistical weights. The weights were later removed, as discussed in the previous section. By the end of Year 1, a preliminary version of the tool using 1995 PG&E CEUS data was online. At the end of Year 2, a new version was released which included an enhanced appearance and interface, substantial documentation and reference information, and additional feature enhancements. The feature enhancements included the addition of SCE CEUS data, separate graphs and results for gas, electricity, and whole-building energy (gas-electric and all-electric), and additional output statistics.

Software development activities in Year 3 focused on debugging and tweaking in response to feedback. Most significantly the bin calculation algorithm was modified and the application of statistical weights was removed, actions which affect the output distributions and graph appearance. An option was added to select between a frequency histogram and a cumulative frequency histogram as the graphic display was confusing to some users. Links to help information are still present in the output for users who still need assistance understanding the graphs. An xml output capability was also added to Cal-Arch to facilitate automated cgi queries by SiliconEnergy (or anyone else desiring xml output) so that Cal-Arch benchmarking functionality can be provided in their preferred format within their own software environment.

2.3.1 Benchmarking Methods

Cal-Arch provides uses distributional benchmarking as a method of comparison. The distribution of EUIs for comparison buildings is displayed graphically in a histogram and summary statistics are provided for each quartile. The data displayed are actual EUI and

are not adjusted for climate or other factor. As part of our analysis we reviewed additional methods and tools. Because gas data were not provided for the SCE CEUS dataset, a procedure to add gas energy-use intensities for each building type within Cal-Arch was considered. Methods considered to develop the gas energy use estimates included DOE-2 simulations, estimates of gas intensities from So. Cal. Gas, or extrapolations from other data sets. Given the available data and budget, satisfactory estimates could not be obtained. Examination of the PG&E dataset showed that there is a large variation in gas EUI within each climate zone and building type so estimates by climate zone would be of little use. Additional advanced benchmarking methods have greater potential for future implementation using 2002 CEUS data. This is described further in the Conclusions and Recommendations section.

EPA Energy Star Analysis

As part of the EPA cost share, Explore Benchmarking Methods for Metric Set, we analyzed additional California CEUS data. The PG&E CEUS data were entered into the EPA Energy Star rating tool for K-12 schools. The 45 locations scored an Energy Star rating at an un-weighted 69% rate and a premise-weighted 87% rate. We are not entirely sure why such a high number of buildings score so well. One factor is that there appears to be a "California Climate Bias" in the Energy Star Rating model. Currently, the models assume that heating degree days (HDD) and cooling degree days (CDD) are consistently correlated throughout the US. As a result of this assumption, the Energy Star model for K-12 schools uses only the HDD. For Census Division 9 (CA, OR, WA, AK & HI) the correlation is not maintained. With a given HDD in California, the Energy Star model assumes a higher CDD and thus predicts that the building needs more cooling energy than the actual CDD. It is expected that the future models for both offices and schools will include both the HDD and CDD terms.

Additional work was done with EPA in regards to energy used by K-12 schools with pools. It was noted that most of the schools with the highest EUIs were those with pools. LBNL developed a simplified "pool correction" method to account for pool energy use which will be incorporated into future Energy Star models (2).

2.2. OUTREACH ACTIVITIES

A number of outreach activities have taken place over the course of the project. This includes presentations and discussions at professional meetings and conferences, research and industry collaborations, and public workshops. Table 2.1 lists outreach activities in chronological order.

Table 2.1. Outreach Activities

August 2000	Initial discussions with Honeywell regarding data sharing and collaborations
May 2001	Presentation at Building Energy Analysis seminar at PG&E's Pacific Energy Center

July 2001	Meeting with SiliconEnergy
May 2002	EPA-CEC discussion regarding Energy Star and California buildings
June 2002	ASHRAE meeting
July 2002	Meeting with PG&E Savings by Design Program
August 2002	Presented conference paper and co-moderated informal session at ACEEE Summer Study
September 2002	Presentation to California Emerging Technologies Coordinating Council meeting in San Diego
November 2002	Half-day workshop at PG&E's Pacific Energy Center
March 2003	Presentation at Rebuild America Technology Seminar, SCE Customer Technology Application Center. Cal-Arch brochure completed and distributed at seminar.
May 2003	Presentation at Current Topics in Applied Statistics conference, Cal State Hayward
June 2003	Paper co-authored by LBNL presented at ECEEE Summer Study
June 2003	Tabletop display and demonstration at ACEEE National Conference on Energy Efficiency as a Resource

2.4.2 Workshops and Meetings

The original plan for Cal-Arch included market transformation activities funded by PG&E; however, these funds were not received. Given the growing interest in benchmarking tools, the original market-based plans were revisited in Year 3 and the Year 3 activities were revised to include collaborations with the utilities, including 2 public workshops held in cooperation with PG&E and SCE. In addition, LBNL presented work on Cal-Arch at the September 2002 meeting of the California Emerging Technologies Coordinating Council (ETCC) and discussed California-related benchmarking issues and the potential opportunities provided by the 2002 CEUS. The ETCC is comprised of representatives of PG&E, SCE, SDGE, and CEC.

Two workshops were scheduled in 2002-2003 to present Cal-Arch to public audiences and to obtain feedback through dialog and paper surveys. Results of the surveys and actions taken are discussed in the Outcomes section and are detailed in Appendix B. The first of these workshops was held in November 2002 at the Pacific Energy Center in San Francisco. This was a half-day workshop dedicated solely to benchmarking and to Cal-Arch and was publicized through the Energy Center's calendar and mailing lists. Instead

of reproducing this event in Southern California, a one-hour presentation was given as part of a well-attended and received Rebuild America and Southern California Edison technical seminar.

A conference paper titled 'Development of a California Commercial Building Benchmarking Database' was presented at the 2002 ACEEE Summer Study on Energy Efficiency in Buildings. Also at the Summer Study, LBNL collaborated with Doug Gatlin (EPA) and Adam Hinge (Sustainable Energy Partnerships) in the development and moderation of an informal session concerning benchmarking and whole-building rating methods. The well attended meeting brought forward numerous technical and market issues regarding benchmarking. Once conclusion was the need to identify key miscellaneous end-use equipment, perhaps the top 10, that may make a large impact on EUIs.

2.5.2 Industry Collaborations

Opportunities for collaborations with Honeywell and Silicon Energy were explored from the early project stages. The interaction with Honeywell aimed to build on our relationship with the Atrium project and discuss the feasibility of data sharing. The Atrium project has since ceased operation. Our partnership with SiliconEnergy explored university building benchmarking. Silicon Energy is working with several campuses in California, including San Jose State, UC Santa Barbara, USC, and Long Beach State. Karl Brown from CIEE has also been working with the University of California to develop benchmarking methods and has expressed interest in collaborating with the LBNL PIER HPCBS benchmarking work. In addition, SiliconEnergy created functionality for its California customers to query Cal-Arch from within EEM Suite.

2.6.2 Energy Star Building Program

LBNL also worked with CEC and the U.S. Environmental Protection Agency to assess the suitability for promoting the Energy Star Buildings Label within the Flex Your Power campaign. As California buildings seemed to meet labelling criteria in higher percentages relative the national population, CEC was concerned that the wrong message would be sent if the label was promoted. Buildings could receive the label even if there additional measures that could be taken to reduce energy consumption. Analysis conducted by LBNL and EPA indicated higher scores on average among California offices; however, a discrepency between CEUS and CBECS left the difference in scores for schools unresolved.

EPA also provided supplementary funds for analysis related to the Energy Star models for offices and schools as discussed in Section 2.1.1. CEUS Data Analysis.

2.7.2 Research Collaboration

LBNL provided Ken Gellespie and ASHRAE TC 9.6 (Systems Energy Utilization) feedback on a work statement to test benchmarking tools at the June 2002 Annual ASHRAE Meeting. Cal-Arch will be included in the tools that will be considered for testing.

In 2003, LBNL collaborated on a conference paper with Bernard Aebischer of the Centre for Energy Policy and Economics in Zurich, Switzerland on energy benchmarks for restaurants and data centers. Using PG&E CEUS data, different metrics for each restaurant type (table service, fast food/self service, and bar/tavern/nightclub) were analyzed and compared with results from other regions. The metrics compared were energy use per square meter, energy use per meal, and energy use per seat. This project also involved researchers from France, Belgium, and Japan.

In December 2002, LBNL met with Helen Mulligan from the UC Berkeley School of Environmental Design. She is a visiting researcher from the UK interested in data to characterize the commercial sector. We plan to incorporate some of her research interests into the Cal-Arch project.

2.8.2 CEC and PIER Contract Linkages

LBNL provided assistance to Schiller Associates and Pacific Northwest National Laboratory in acquiring and managing CEUS data for use in their PIER work.

LBNL has been working on benchmarking issues that have involved extensive discussion with NBI and their work with the CEC and EPA on the relationship between code and Energy Star scores. Though this is not directly related to the PIER buildings programs, it is related to CEC's work with NBI and code. (See the ACEEE 2002 paper by Jeff Johnson). LBNL also corresponded with Daryl Mills at the CEC who expressed interest in LBNL's analysis of school energy use data. LBNL has also worked with other Collaborative for High Performance Schools (CHPS) partners including Greg Ander and Charles Eley and was involved in discussion between EPA and CEC regarding the Energy Star buildings label and California (Section 2.6.2).

2.9.2 Technical Advisory Group

3. Outcomes

3.1. CAL-ARCH SOFTWARE

Cal-Arch can be used from any web browser on most operating systems by pointing to http://poet.lbl.gov/cal-arch/. The software functionality is described here. User help information and reference material are also included on the user-friendly website.

3.1.1 User Interface

Cal-Arch is intended to be a simple tool that is quick and easy to use, and thus a minimum number of user inputs are requested. Figure 3.1 shows a snapshot of the user input page. The only inputs requested are building type, zip code, floor area, energy consumption, site/source selection and graph type selection. Users who do not have their own data on hand can still use the tool to browse EUI distributions according to the search criteria (building type, floor area, climate zone). Information on each input field is given below.

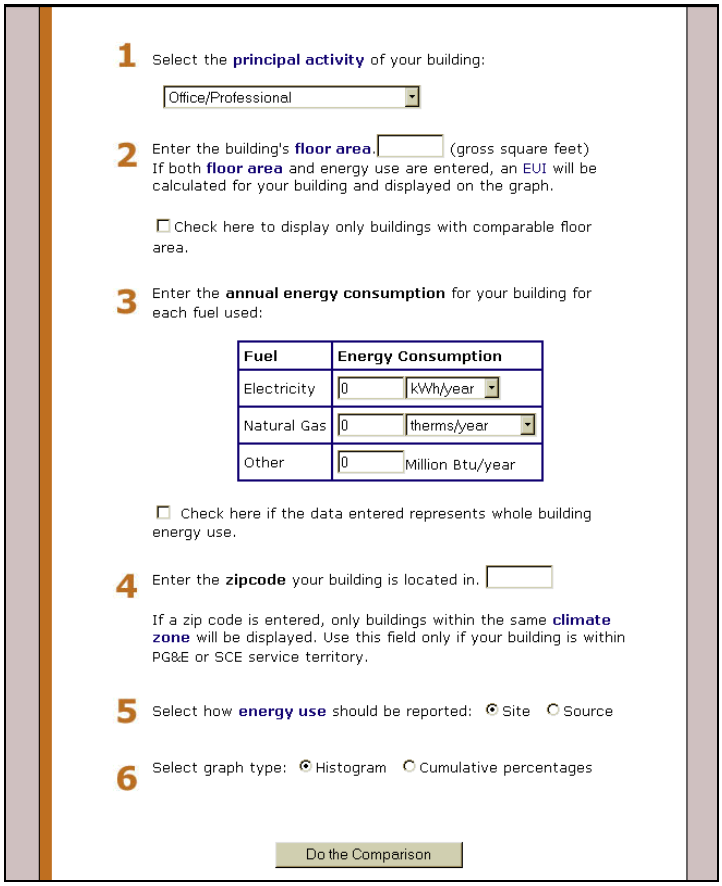

Figure 3.1. Cal-Arch Input Page

Building Type

The building type is defined to be the building function occupying the most floor area. The categories for building type in Cal-Arch have been designed to correspond roughly to CBECS categories. This was done for consistency, familiarity, and to increase sample sizes for each category. Table 3.1 shows how CEUS categories were mapped to CBECS categories for use in Cal-Arch. Title 24 categories are also shown as the Non-Residential New Construction Survey (NRNC) has also been considered for inclusion in the Cal-Arch database.

Table 3.1. Building Type Correspondence

CBECS Category	CEUS Category	Title 24 (NRNC)
Agricultural	Agricultural	
Education	Daycare Elementary/Secondary College Vocational or Trade School	School
Enclosed Shopping/ Mall	Shop in Enclosed Mall	
Food Sales	Supermarket Convenience Other Food Store	Grocery Store
Food Services (Restaurant)	Fast Food or Self Service Table Service Bar/Tavern/Club/Other	Restaurant
Health Care (Inpatient)	Hospital	
Health Care (Outpatient)	Medical Clinic/Outpatient Care	Medical Clinic
Industrial Processing/Mfr	Assembly/Light Med/Heavy Food/Beverage Processor	
Lodging (Hotel/Motel/Dorm)	Hotel Motel Resort	Hotels/Motels
Nursing Home	Nursing Home	
Office/Professional	Administration Financial/Legal Insurance/Real Other Office	Office
Public Assembly	Recreation or Other Public Assembly	Religious, Auditorium, Theater Community Center Gymnasium, Library
Public Order & Safety		Fire/Police/Jail
Religious Worship	Church	Religious, Auditorium
Retail (except mall)	Department/Variety Other Retail	Retail & Wholesale
Service (except food)	Gas Repair/Non-Auto Other Service Shop	
Warehouse (non-refrigerated)	Warehouse (non-refrigerated)	C&I Storage
Warehouse (refrigerated)	Warehouse (refrigerated)	C&I Storage

Floor Area

Gross floor area is requested from the user in order to calculate their EUI and it is also one of the variables that Cal-Arch allows you to filter the comparison buildings with. In CEUS, the survey unit is a "premise" rather than a "building". A premise may be all or part of a building, and sometimes more than one building, but is usually a single utility customer billing account.

Climate Zone

The California Energy Commission recognizes sixteen climate zones in California. As CEUS contains zip codes, these are easily mapped to climate zones. For sample size purposes it is advantageous to narrow the climate zones to four categories as illustrated in Figure 3.1.

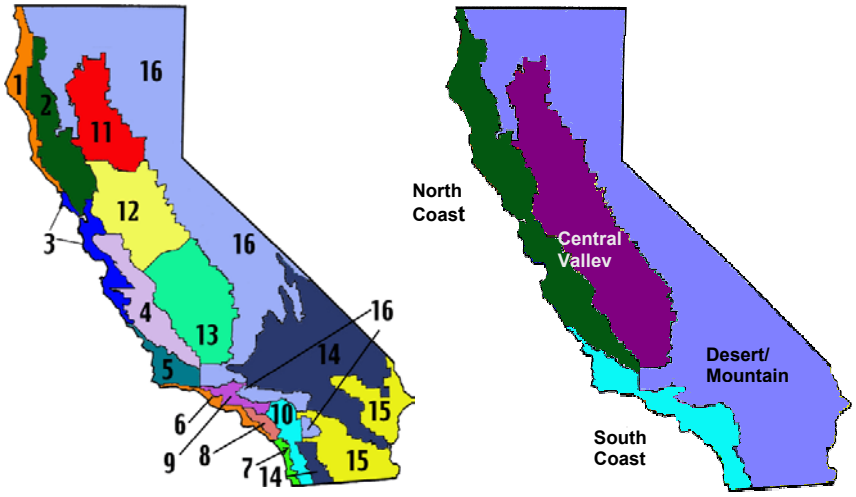

Figure 3.1. Climate Zones

Whole Building Energy

Annual energy use data used to calculate EUI is usually obtained from utility billing data. Billing data were included in CEUS; however, for SCE CEUS only electric bills were provided and for PG&E CEUS, only gas and electric. Hence, whole-building energy use is not available for all buildings in CEUS. Part of the analysis of CEUS was to determine which fuels are used by each site and to assess whether the energy use reported represents 'whole-building' energy. Especially important in benchmarking electricity use is determining which building are all electric. The electric EUI for an all-electric building represents whole-building energy use while the electric EUI of a building with gas heat does not.

Site/Source Energy

An option is provided to display results in units of source energy or site energy. Site energy is what most users are familiar with as it is the amount of energy which they use and are billed for. Source energy accounting is used to make comparisons of the true impact of consumption as it accounts for losses in transmission and generation. The site-to-source conversion factors used are 2.7 for electricity (3) and 1 for natural gas. The actual values vary by fuel type and location.

Graph Type

Users may select to have frequency histograms or cumulative frequency histograms included in their output as shown in Figure 3.2.

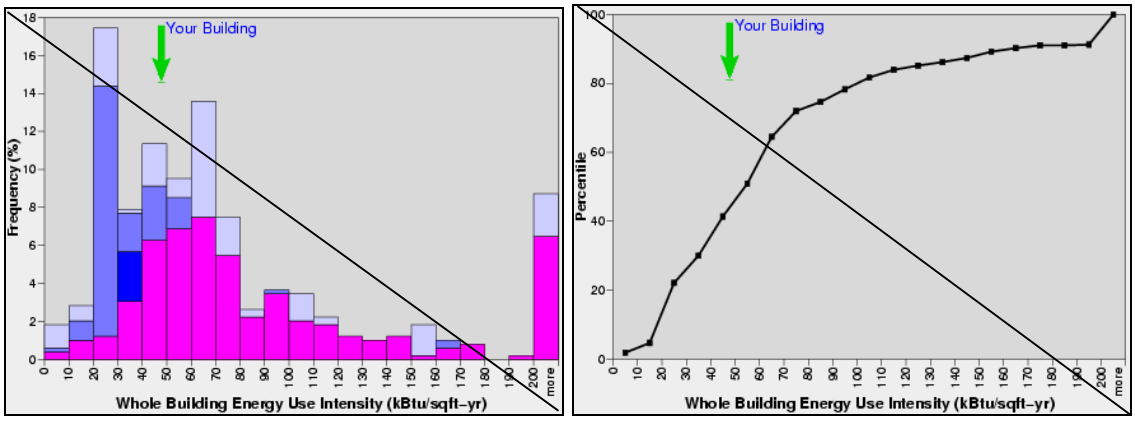

Figure 3.2. Graph Types

Results

Depending upon the inputs entered, the Cal-Arch database is queried and the results are displayed as a histogram displayed with statistics describing the comparison buildings and the user's EUI. Additional information is provided to aid in the interpretation of the results as well as links to further information about the data sources and other benchmarking tools. Figure 3.3 shows a sample histogram and summary for whole-building energy use. Similar results are produced for electricity and gas use comparisons. Figure 3.4 shows an example of the legend and additional information provided with the output.

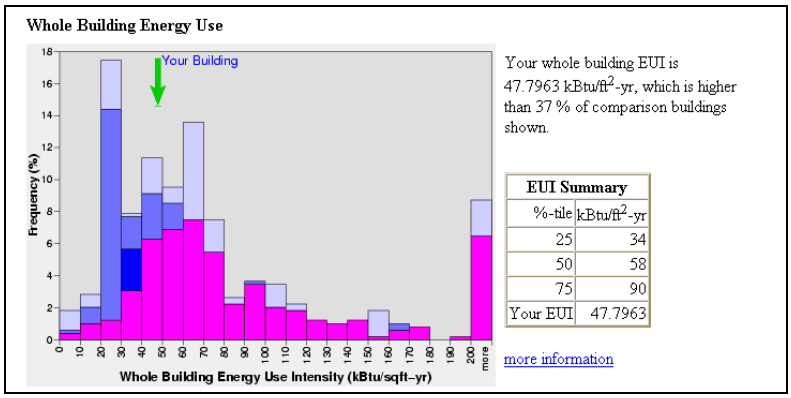

Figure 3.3. Output Display - Summary

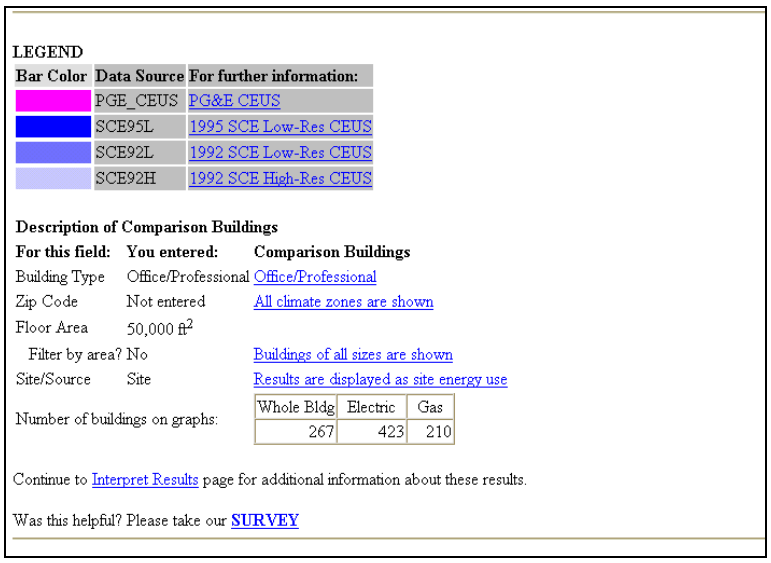

Figure 3.4. Output Display - Legend

3.2. TECHNICAL REPORTS

Several reports and technical memoranda were produced during this project, many of them specific project deliverables. Appendix B lists project deliverables and their anticipated and actual dates delivered.

- The first technical report was a software specification for Cal-Arch completed in January 2001 (4). Some revisions to the specification were made in the Year 2 Final Report to accommodate the addition of two public workshops.

- A technical report on existing benchmarking methods and tools was submitted in July 2001 as a Year 1 deliverable (5).

- The paper "Development of a California Commercial Building Energy Benchmarking Database" discussing the development of CEUS data for

benchmarking and the benefits of regional benchmarking was presented at 2002 ACEEE Summer Study on Energy Efficiency in Buildings in August (6).

- The Cal-Arch brochure was the first in a series of HPCBS brochures (7). It was completed in March 2003 and was distributed to attendees of the Rebuild America Technology Seminar in Irwindale, CA on March 13th.

- LBNL contributed to a paper titled "Energy efficiency indicators for high electric-load buildings" which was presented at the 2003 European Council for an Energy Efficient Economy Summer Study in France by Bernard Aebischer of the Centre for Energy Policy and Economics in Zurich, Switzerland (8).

3.3. FUTURE PLANS

A fourth project phase has been approved which will primarily focus on outreach activities and planning for a more a potential future Cal-Arch which would incorporate 2002 CEUS and more advanced functionality. This project will have 3 primary components:

- Additional research and analysis of K-12 schools benchmarking, partnering with the California High Performance Schools Collaborative (CHPS)

- Collaboration with Energy Information System vendors to embed Cal-Arch directly in their tools

- Planning activities to support the development of a more advanced Cal-Arch to build on the Dr. CEUS database being developed by RER for the California Energy Commission.

4. Conclusions and Recommendations

Building energy benchmarking is a valuable step in many energy efficiency projects, whether new construction, retrofit, tune-ups, or ongoing operations analysis. Design engineers, building owners, and operators often seek information to understand how their building compares with others.

The web-based benchmarking component of the HPCBS Program has focused on the development of Cal-Arch, a tool for benchmarking energy use in California buildings. The primary source of data for this tool is the 1992-1995 CEUS. The interest in this type of program has been demonstrated over the course of the project, through meetings, presentations, and workshops, with utilities, industry partners, and target users (building managers, energy analysts, etc.).

This tool will cease to be useful if the data are not kept up to date. The release of 2002 CEUS data will present an opportunity to greatly enhance the usefulness of this tool and to integrate more advanced benchmarking methods.

5. Acknowledgments

Other LBNL staff who have contributed to this project include Brian Smith, Krister Udd, Alan Meier, Bruce Nordman, Norman Bourassa, and Mithra Moezzi. We are also grateful to Martha Brook and Lynn Marshall (California Energy Commission), Bob Rose and Tom Hicks (Environmental Protection Agency), Anne McCormick, Sam Cohen, and Robert Sonderegger (SiliconEnergy). This work was supported by California Energy Commission Public Interest Energy Research Program and by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology, State and Community Programs of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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Appendix A. Milestones and Deliverables

Description	Start Date		Due Date	
	Planned	Actual	Planned	Actual
Technical memorandum on the evaluation of California data sets	7/15/00	8/1/00	7/14/01	7/14/01
Technical memorandum on benchmarking methodologies	7/15/00	8/1/00	7/14/01	7/14/01
Specifications for modifications for existing benchmarking software to include California data sets	7/15/00	8/1/00	2/10/01	2/10/01
Operational web-based benchmarking tool with California data sets	7/15/00	8/1/00	7/14/01	7/14/01
Enhanced benchmarking database	7/15/01	7/15/01	7/01/02	
Final benchmarking tool and report evaluating benchmarking with advanced normalization procedures	7/15/02		7/14/03	

Appendix B. Survey Responses

To date, 20 long surveys and 50 short surveys have been completed. Five of the long surveys were completed online and fifteen at the workshop on November 21st. One person completed both online and paper versions. The only difference between the two is that on paper many people chose multiple options where they were given; whereas on computer they are restricted to one choice. According to Ryan Stroupe, 17 people attended the workshop, so 15 responses represents a very high response rate. One non-responder is known to have completed the online version. The short surveys were administered at the March 13th workshop in Southern California.

A companion spreadsheet contains complete responses for each survey. This appendix summarizes results by question.

B.1 SUMMARY OF RESPONSES

B.1.1 Long Survey

General Information

1. What is your job/role:

The most common response was Other (8) followed by Service Provider (7) and Owner/Manager (3). The job titles included under Other included Consultant, Systems Engineer, Electric Utility Energy Analyst, Consulting Engineering/Manufacturer, Business Dev (marketing) for large commercial projects, Energy Engineer (2), Energy Consultant (2) , and Major Account Manager (PG&E).

2. Types of buildings you deal with mostly:

Most paper respondents selected multiple options. The most common response was Office (13). Others were Retail (7), Medical (5), and Education (7). Responses to Other included Residential (2); Fed. Govt, Labs, etc; Industrial, Hotels/Restaurants, Fitness, and Manufacturing, All of the Above (2).

3. Typical size of buildings you deal with:

Again, several respondents responded to multiple categories. The total tally was

< 10,000 sqft (5), 10-50,000 sqft (8), 50-250,000 sqft (10), >250,000 (7).

Usage

4. Have you used Cal-Arch before today? **5** Yes **14** No **1** NR

5. Have you used Energy Star Portfolio Manager? **4** Yes **15** No **1** NR

6. Have you applied for an Energy Star Buildings Label?

Three responders have applied for Energy Star Labels. One reported 20+ buildings applied and receiving the label; another, ~45 received out of ~50 applying; and the last, 1 of 1.

7. Have you used any other tools for benchmarking whole building energy use? Please list any other tools you have used:

Eight people listed tools they had used. Of these, two had answered No to the first part of the question. The tools listed include Arch, CBECS, Emcor Energy Edge, Equest, LEEDS, T-24, EnergyPro (DOE-2), Energy Star (perhaps should add this to Q.5), Excel spreadsheets, BOMA, Emcor (internal tool), and Honewell's MyFacility website.

8. How often do you use or plan to use benchmarking tools?

Nine (9) answered Once in a while (or equivalent); three (3) were about once a month, and four (4) were about once a week. One person answered "would like to start" and three did not respond.

9. How will you/your customers use Cal-Arch?

Sixteen (16) people responded to this question. Of these, two (2) were uncertain. Of the remainder, six (6) mentioned preliminary audit/evaluation; two (2) mentioned reporting and communication; the remaining comments included retrofit energy savings, incentive programs, evaluations for design, screening, and comparison. See spreadsheet for complete responses.

10. How do you expect it to benefit you or your customers?

Thirteen (13) people answered this question. Most of these referred to relative comparisons, demonstration of opportunity, targeting buildings, etc. One mentioned marketing image. Some were more specific than others; see spreadsheet for complete responses.

Inputs

11. Are the instructions clear?

16 Yes **0** No **3** NR **1** mostly

12. Is the requested information easy assemble? **15** Yes **1** No **4** NR

Are the fields for querying (building type, climate zone, etc) sufficient for finding similar buildings? **12** Yes **4** No **4** NR

One write-in comment suggested "instead of current display, group filters together".

13. How important are the following criteria for a benchmarking tool?

Five (5) people answered Very Important for each field listed and two (2) answered Important for each. Ten (10) had mixed responses and three (3) did not respond at all.

Criteria	Unim-portant	Don't care	Important	Very Important	No Response
Building Type			5	12	3
Floor Area			5	12	3
Climate Zone			5	12	3
Building Age			10	7	3
Heating Type		1	9	7	3
Cooling Type		1	9	7	3
% Heated		2	7	7	4
% Cooled		2	8	6	4

14. What additional characteristics (search fields) would be useful ?

Seven (9) people responded to this question. Four (4) mentioned hours of operation or occupancy and one (1) mentioned system type. Also requested were prorations for mixed-use buildings, breakdown of gas usage for water heating, and HDD/CDD.

15. Additional comments on input fields and input page:

There were three (3) additional comments. One person was interested in accounting for district steam and gas cooling. One person suggested that filters should be able to be activated and deactivated after each iteration (I think this is more or less the case). The last was interested in an interface similar to portfolio manager, ie, tracking over time.

Output

16. Are the graphical displays useful to you? **14** Yes **2** No **5** NR

17. Are the summary statistics useful to you? **13** Yes **2** No **6** NR

One Yes response was qualified by "but less so" presumably relative to the graphical display. One No response wrote in "need to explain".

18. Do the results seem plausible? **12** Yes **1** No **6** NR

The one No response was the online survey taken by the person who repeated it on paper (I don't know which paper response is his). So he either changed his mind or declined to repeat his statement. Interestingly enough, the results on the whole-building graph changed the day after this event when Brian fixed an error in the whole-building energy calculation.

19. Any additional comments on the graphical displays and summary statistics:

20. Please provide any additional comments about the results, their usefulness, and any action you might take based on them

21. Please provide any additional comments about the Cal-Arch tool and website

In retrospect some of these questions are redundant and in some places comments appear to be answers to different questions. In any case, the primary intent of the survey was to illicit comments.

Ten (10) people responded to at least one of these questions; most only to one, so I'll summarize the responses all at once. Three (3) were generic or uncertain. Three (3) expressed concerns with the limitations due to sample size and non-whole building energy use. One person pointed out a bug in the program, which was subsquently fixed.

Six (6) offered specific suggestions for improvement: first, to give the real energy costs, carbon emissions, etc as summary outputs. To some extent we have this with the Source energy option, but we could hard-wire it to give both, but not just in kBtu but in lbs of coal or emissions, etc.; second, to make it more friendly to facility managers and property managers; third, to include cost information; fourth, to include energy standards, mentioned twice; and fifth, to include max, min, mean, and standard deviation, which I have explained my disagreement due to the skewness of the EUI distributions.

Contact

22. Which electric utility service territory are most of your buildings located in?

12 PG&E SCE SDGE

1 SMUD **1** LADWP Other Calif.

2 Other US Outside US **1** Varies

23. Would you be willing to share data on one or more buildings? **5** Yes **14** No/NR

24. If so, or you are otherwise open to future contact, please provide your contact info.

Six people gave names and contact information

25. Please add any additional comments you may have.

Five (5) people had some extra comment, in this field or outside of any specific field. Two were generic. One was mostly illegible but seemed to say something about importance of speed and ease of use. Another appeared to be an incomplete thought related to the "team integration" approach of LEEDS and communicating information to different parties (owner, users, architects, etc.). The last expressed the desire for similar functionality in a tool for all of the U.S. or North America.

B.1.2. Short Survey

General Information

1. What is your job/role?

The most common response was Other (21) followed by Owner/Manager (15) and Service Provider (11), Operator (5), and Manufacturer (3). The roles listed under Other included architects (8), utilities (3), and energy manager/analyst (3). Total responses: 49

2. Types of buildings you deal with mostly:

The most common response was Office (22). Others were Retail (13), Medical (16), Education (10), and Other (19). Responses to Other included Industrial/Manufacturing/Lab (8) and All/Varied (3). Total responses: 49

3. What benchmarking tools have you used before?

Energy-10	1
Energy Cap	1
Title 24	1
DOE-2	1
Other analysis	11
Utility bills	2
SCE resources	1
Energy Star	1

4. How often do you plan to use benchmarking tools?

Never	7
Occasionally	26
Regularly	12

Total Responses: 45

5. How will you or your customers benefit?

Comparisons	Compare energy use & plan changes of equip or construction	8
Design	Specify through design process & advise clients w/existing bldgs	5
Targets	Look for potential energy savings & maintenance tasks, set goals	5
Lacking	Would like to have a natl tool, does not apply to my facility type	3
Programs	Selection programs, LEED documentation	2
Money	Save $, To check energy budgets	2
Glazing	Look for glazing, Deltas	1
Service	Provide better service for our customers	1

Total Responses: 27

6. What are the most important selection criteria?

Note: Leaving this open-ended resulted in some interesting responses; apparently some people misunderstood the question.

Building Type	17
Size	15
HVAC	8
Location, Climate	7
Age	7
Building Envelope/Contruction	5
Shape, Style, Orientation, Shading	5
Lighting Requirements or Type	4
Window, Roof Construction	4
Occupancy	4
Heating load, PCs, electronic equipment	3
Daylighting	1
Energy Source	1
Schedule	1
Suburban/City	1

Total Responses: 30

7. Is Cal-Arch easy to use?

Yes	34
No	3
Maybe/Other	1

Total Responses: 38

8. Are the graphics and summary statistics useful?

Yes	25
No	7
Maybe/Other	2

Total Responses: 34

9. Is Cal-Arch useful to you in its current form?

Yes	17
No	15
Maybe/Other	3

Total Responses: 35

10. Will the addition of more Southern California data make it more useful?

Yes	37
No	2
Maybe/Other	1

Total Responses: 40

11. Are you willing to share data on one or more buildings?

Yes	20

12. Contact Info

    Total Responses: 13

13. Additional Comments

Thanks/Good Presentation	4
Will try the program	3
Other	2

Total Responses: 9

B.2 RESPONSE TO FEEDBACK

The following are key points that arose during the discussion at the November workshop:

1. Minimum data set. For some queries, few or no buildings will be returned, particularly if the number of query fields is increased. So the suggestion is that we define a minimum number of buildings that must be returned in order for results to be generated.

   A five-site minimum was implemented in tandem with the removal of weights for masking purposes.

2. Colors. There may be better variables that could be represented by color rather than data source.

   This should be considered in future implementations.

3. Weighting. As could be expected, the use of weights is initially confusing, particularly as the weighted number of buildings is given in the legend (should be removed) before the table at the end of the results summarizing weighted and unweighted numbers.

   The use of weights in Cal-Arch has been removed and no references to weights remain in the output.

4. Important attributes. The hours of operation has been the characteristic of energy most often mentioned. Vintage is another important attribute.

   Information on additional key attributes should be considered for future implementation.

5. Graphing methods. Some people like the current method; others prefer simpler graphics. An option to choose between frequency histogram, cumulative frequency histogram, or both (current method) would be easy to implement.

   Users now have the option to choose between frequency or cumulative frequency histograms.

6. Targets. The current results produced by Cal-Arch are interesting but a little too fuzzy for some people. We do not tell them if they are efficient or not. Many people indicated they would like to compare to "best" buildings, standards, etc.

   We do not feel it is appropriate in this context to say whether or not a building is efficient; however, some assistance in interpretation is provided. Incorporation of published benchmarks could be included in the future if they are clearly defined and do not confuse the results. A future Cal-Arch based on 2002 CEUS data could be used to provide more advanced information with simulated results.

7. End uses. We have noted in the past, particularly in our schools analyses, that often the high EUIs correspond to buildings with more end uses. For example, pools were present in most of the schools with high EUIs.

   This is a complicated issue which we have explored in our discussions with Energy Star and which is discussed briefly in our 2002 ACEEE paper.

Appendix C. Electronic Attachments

The program underlying Cal-Arch and associated documents are archived in the HPCBS internal website under Task 2.1.1. The following are included:

(more detail to come)

- Program files & documentation
- SAS files
- Surveys, response tally spreadsheet
- ECEEE paper, brochure, other non-deliverable publications
- Presentations