FINAL REPORT

Project Title:
Arkansas School Utility Benchmarking Project and Internships

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ABSTRACT

Beginning in August 2004, eight school districts volunteered to participate in a pilot utility tracking program sponsored by the Arkansas Department of Education and the Arkansas Energy Office. The participating districts were Camden-Fairview, Fayetteville, Fort Smith, Jonesboro, Marion, Mena, Nettleton, and Pine Bluff. With support from the state, each district began entering historical water, natural gas, and electricity usage data for each of their utility meters into a commercially available online utility tracking service – SchoolDude.com's UtilityDirect. In May 2005, five University of Arkansas undergraduate mechanical engineering student interns were hired and trained to assist the school districts in obtaining and entering the utility data. In addition to data entry, each intern was required to compute utility benchmarking indicators for each school for later analysis. Along with the benchmarking data and analysis for the eight participating school districts, this report contains results and analysis from a district superintendent survey, a brief description of summer intern experiences, and overall conclusions and recommendations relative to helping schools and impacting the State of Arkansas.

In general, this project produced several positive outcomes, including high-quality summer experiences for the mechanical engineering interns; new and positive interactions between K-12 school districts and University of Arkansas personnel; a benchmarking study with useful values for the eight participating districts and other state school districts; and survey findings that provided insight into the needs of Arkansas schools with regard to building performance, building operation, utilities, and maintenance. Future recommendations discussed in this report include making a strong effort to assist the smaller school districts; extending the use of the benchmarks provided in this report, providing school districts a simpler mechanism for tracking utilities; and continuing to utilize engineering interns to assist the state with energy/environmental issues.

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Chapter 1

INTRODUCTION AND PROJECT DESCRIPTION

The costs of operating buildings this winter is expected to increase greatly due primarily to rising costs of natural gas and heating fuel oil. According to the Department of Energy's Energy Information Administration [1], U.S. residents using natural gas as their primary heating fuel are projected to pay an increase in price of 55% as compared to last winter. Closer to Arkansas, natural gas expenditures in the southern part of the United States are expected to increase 39%. Similarly, small and medium-sized buildings, like K-12 school buildings, can expect to pay significantly more for utility costs this winter. All of this means that operating budgets for school districts in Arkansas will be strained to pay for higher utility costs. Therefore, any effort to conserve utilities has the potential to significantly impact school districts' operating budgets.

Beginning in August of 2004, eight school districts volunteered to participate in a pilot utility tracking program sponsored by the Arkansas Department of Education and the Arkansas Energy Office. The participating districts were Camden-Fairview, Fayetteville, Fort Smith, Jonesboro, Marion, Mena, Nettleton, and Pine Bluff. With support from the state, each district began entering historical water, natural gas, and electricity utility data into a commercially available online utility tracking service – SchoolDude.com's UtilityDirect. In May 2005, the Arkansas Energy Office contracted with the University of Arkansas' Mechanical Engineering Department to assist the process. Their major objectives were to 1) hire mechanical engineering students as summer interns to assist each school district enter their utility data, 2) analyze the utility data through benchmarking, 3) survey Arkansas school district superintendents to better understand the needs of Arkansas schools relative to building performance, building operation, utilities, and maintenance, and 4) compile a final report. The first three were completed by September 30, 2005.

The success of this project relied heavily on the use of University of Arkansas undergraduate mechanical engineering students, living during the summer at different locations across the state. The students were managed, trained, and assisted by Dr. Darin Nutter, an associate professor in the University of Arkansas Mechanical Engineering Department. Each student attended a one-day workshop training session in Fayetteville prior to visiting and assisting the school districts. Then, during June through August, four of the students worked with the school districts to help complete the task of obtaining and entering the utility data for all electricity, natural gas, and water meters. The students also computed utility benchmarking indicators for each school for later analysis. Along with the benchmarking data and analysis for the eight participating school districts, this report contains results and analysis from a district superintendent survey, a brief description of summer intern experiences, and overall conclusions and recommendations relative to the State of Arkansas.

Chapter 2

INTERN ASSISTANCE PROGRAM

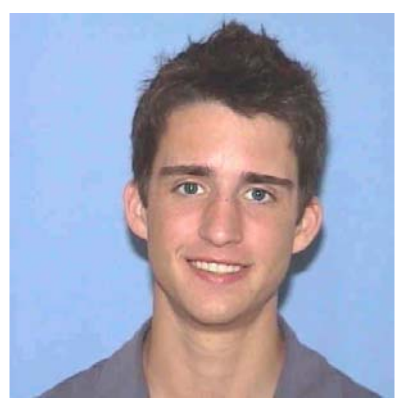
Dr. Nutter interviewed approximately 20 applicants and hired five interns who were all mechanical engineering students. Each student's picture is shown below with their corresponding summer districts and/or responsibilities. Four of the students actively interacted with the school districts (Bradley, Degges, Miller, and Thrift). During the summer time away from the University of Arkansas, they resided in their home town, near one or more of the eight participating school districts. Prior to the internships beginning, Dr. Nutter contacted representatives for each school district to obtain proper permissions and to assess the current status of their utility data entry. All eight districts were receptive to receiving student help. Seven of the eight districts had, at various levels of completeness, been entering all three utility types (electricity, natural gas, and water); however, one only tracked energy (electricity and natural gas). In general, this district felt that collecting water data had less benefit as compared to their other utilities. The district had done an excellent job of tracking their electricity and natural gas and was current with all other data entry. Therefore, the four interns concentrated on the other seven districts.

Warner Bradley
(Fayetteville and analysis)

Matt Degges
(Nettleton, Marion, and Jonesboro)

Jay Keazer
(benchmarking analysis)

Chris Miller
(Pine Bluff and Camden/Fairview)



Philip Thrift
(Ft. Smith and Mena)

Figure 2.1. Pictures of the five University of Arkansas Mechanical Engineering summer interns and their corresponding summer districts and/or responsibilities.

Intern Training, Successes and Lessons Learned

The student interns traveled back to Fayetteville, Arkansas for a one-day training session related to their summer tasks. After introductions and detailed description of the pilot program, Dr. Nutter spent most of the day giving the students a crash course in understanding energy use and costs associated with K-12 buildings in Arkansas. In addition, he provided training on *SchoolDude's UtilityDirect* website. Numerous examples of utility rate structures and the factors that influence costs based on usage and rate were explained. Following several hours of group training, break-out sessions were used where Dr. Nutter met one-on-one with each of the students to explain and give specific assignments related their school district(s). The training seemed to be very helpful for the students, plus it allowed the PI to get to know each student a little better.

During early June, four students started interacting with four of the school districts. Dr. Nutter visited each location, introduced the student to the school district's main contact, initiated interaction for each intern, explained the Arkansas Energy Office desires to help each district, and facilitated the student intern's needs. Dr. Nutter was extremely well received and the students even more so. The remaining three districts were visited by Dr. Nutter on July 15, 18, and 21, respectively. Again, the last three districts are very receptive to intern assistance.

In most cases, students were given office space and assistance acquiring copies of utility bills. Some student interacted with local utility companies in an effort to obtain summary or bulk information related to historical data. Each student had a unique 'energy engineering' experience, but they all had valuable experiences as they were allowed to interact with many facilities professionals, the business/office setting (some for the very first time), and clerical and maintenance personnel. Most, if not all, of the interns were introduced to an aspect of engineering they had not previously envisioned. At the end of the summer, many of the students expressed interest in potential engineering careers related to building systems and building operations. In addition to direct benefits to the schools (intern assistance) and the students (experience and summer work), the State of Arkansas has gained as well through: 1) utilizing university students for a somewhat technical task they were well suited to perform, 2) allowing personal interaction between Dr. Nutter and numerous school districts professionals, and 3) the positive completion of the pilot utility tracking program.

In six of the seven districts with intern interaction, it was quickly learned that the responsibility for entering utility data had been delegated to a person not very familiar with utilities. There were numerous reasons for this, including personnel changes and limited time. Entering two or more year's worth of utility data for districts that have up to 100 buildings proved to be a very tedious task. In many cases, the student interns had to correct previous data entry errors and inconsistencies. They also added monthly peak electrical demand data for all electric meters – original instructions to the schools were to only enter cost and usage values. Where incomplete, the students entered building areas and school student populations. One relatively obvious finding was that the schools already have so many required paperwork and documentation demands, that it is difficult to expect very much more will be done, especially by the facilities manager.

Chapter 3

IMPROVING PERFORMANCE THROUGH BENCHMARKING

Introduction

As a general definition, benchmarking is defined as the process of systematic and continuous measuring and comparing one's processes against comparable processes in leading organizations to obtain information that will help one to identify strengths and weaknesses of their existing performance. There are six basic steps to improving performance through benchmarking. They are: 1. identify key variables, 2. select good comparable sources, 3. collect and measure performance data, 4. normalize and adjust to meaningful data, 5. analyze data, and 6. change and improve performance [2].

Each of the above steps needs to be addressed to incorporate the benchmarking process to reducing utility costs for Arkansas K-12 school buildings and districts. This study addresses the first five steps of the six-step process. It will take further efforts, at both the state and district levels, to make the necessary adjustments and improvements that will lead to significant reductions in utility costs. The key variables (step 1) in this pilot study were determined to be electricity, natural gas, and water. Utility benchmarking parameters for buildings within eight school districts across Arkansas were chosen for comparison (step 2) along with historical data for similar buildings available in the public domain. The majority of effort by the student interns this summer was to facilitate the collection of measured utility data for all available building meters within each district (step 3). Building-related benchmarking parameters were computed for each utility type (Step 4) and included overall cost and consumption per unit area, and per student. In addition, important electricity-related indices such as power per unit area, electrical load factors, and others were determined. Adjustments for weather normalization were not made to the data due to the fact that all buildings were located in the same state and same general weather region. Future minor adjustments of the data may include weather normalization, but it is not expected to create significant changes in the data trends or analysis. The data, along with analysis and discussion (step 5), are provided in this chapter. Although not nearly comprehensive, this project has begun the process of benchmarking Arkansas K-12 school buildings and should help participating school districts identify buildings that have significant potential for reducing utility costs and provide other state districts the reference benchmarking data for comparing their own school buildings.

Background and Previous Benchmarking Studies

The nationwide focus on energy prompted by the energy crises of the 1970's led to an abundance of professional papers published in the late 1970's and 1980's in the area of measuring and minimizing building energy usage. Many of these studies were conducted using public school buildings, presumably because of the ubiquity of these types of buildings and their tendency to be government-funded. The recent increase in energy prices has given these types of studies new relevance. The section below briefly describes some of the past studies and other available school building utility data.

The U.S. Energy Information Agency, a department of the U.S. Department of Energy, publishes detailed information on a large sample of commercial buildings every four years in their Commercial Building Energy Consumption Survey (CBECS) [1]. One building type subgroup within the commercial sector is educational buildings. The most recent complete and available data set is for the year 1999 and will be compared to the Arkansas pilot utility tracking data later in the results sections of this chapter.

Graham [3] (1977) measured energy usage of a public school district in Canada over a five-year period. For comparison between schools, energy usage data was normalized by floor area and corrected for climate fluctuations using heating degree days, resulting in units of kWh/m^2-°C-day. Several retrofits and energy management programs were implemented and changes in energy consumption were tracked over the time period.

Hodge and Steele [4] (1982) studied a "typical" school in Mississippi and compared results to a state-wide energy survey in 1978-1979 by the Mississippi Energy Extension Center. The index used for comparison is termed the Energy Utilization Index (EUI), the total site energy used per square foot per year. The authors state that, for mild climates, school buildings using 80 kBtu/ft^2-yr or more are relatively inefficient, and those using 30 kBtu kBtu/ft^2-yr or less are relatively efficient.

Monts and Blissett [5] (1982) suggested that adjusting a building's EUI by multiplying a degree-day ratio to account for climatic variations was a "severely limited" approach when dealing with the commercial building sector. The authors proposed that a building's Energy Utilization Index could be described as a function of several variables including climate, HVAC system design, indoor design temperature, building envelope thermal integrity, and building use. This built upon the work of Dubin, Mindell, and Bloome (1975). Using linear regression, their results indicated that 42% of the variance in EUI could be explained by climate, HVAC system design, occupancy patterns, and building use.

A study of Iowa Public School Buildings [6], published in 1984, categorized each school in the study as 'energy superior' or 'energy excessive,' and determined which variables in their survey had a significant correlation with energy usage. The method used for categorization was called the Building Energy Management Index, or BEMI. Monthly Values of BEC (Btu/ft^2-°F-day) and BFC (occupant-hours/ft^2-°F-day) were computed for each school. These values were based on heating degree days only. All monthly values were plotted, and a best fit line was drawn, with a corresponding confidence interval. Buildings with more than 3 points falling above the confidence interval were put into the 'energy excessive' category, while buildings with 11 or more points below the confidence interval were termed 'energy superior.' The most highly correlated variable was the amount of air infiltration, as estimated on a scale of 1 to 9 by the building maintenance supervisor.

School and University Magazine's annual Maintenance and Operations Cost Study [7] details electric, natural gas, and other utility expenses based on a nationwide survey of public school districts. The survey data are expressed in both dollars per student and dollars per square foot. Some publication years contain data categorized by region, while others only contain national median data. The 1999 survey results containing regional data have Arkansas grouped with four other nearby states -- Louisiana, Oklahoma, New Mexico, and Texas.

In 1996 the Florida Solar Energy Center conducted an Energy Survey of Florida Schools [8], in which schools were ranked by their EUI (Btu/ft^2) in order to select those schools most suitable for energy saving retrofits. The study also identified several variables having a statistically significant correlation to annual energy usage. Parameters that had a correlation with lower energy use included the presence of operable windows, ceiling fans, and manual HVAC controls. Parameters identified as increasing annual consumption included, not surprisingly, amount of floor area and students, as well as utilization of clock-based and sensor-based lighting controls.

In 2001 the Canadian Office of Energy Efficiency's Energy Innovators Initiative produced the *Benchmarking Guide for School Facility Managers* [9]. Energy consumption and benchmarking energy performance data for 4,243 schools during 1997-1999 were reported. Primary benchmarking parameters included both normalized annual energy consumption (electrical kwh) and annual energy costs ($) per unit area ($m^2$). National and regional schools of similar energy performance were compared and general observations made regarding energy trends and variables that impact consumption and cost.

The U.S. Department of Energy created the Rebuild America Program [10] in 1994 to initiate energy-efficiency, energy technology, and pollution reduction projects. Rebuild America's Energy Smart Schools program takes part in construction, transportation, and energy education projects to achieve energy savings in the nation's K-12 schools.

The U.S. Green Building Council [11] has created a rating system known as LEED (Leadership in Energy and Environmental Design) to evaluate a building's overall environmental performance. Brzezowski [11] describes the approach New Jersey schools have taken to build more environmentally sustainable and energy-efficient buildings by requiring that all new school designs conform to LEED standards. The LEED certification and points rating system includes points for sustainable site design, water efficiency, energy use and atmosphere effects, renewable materials and resources, indoor air quality, and innovations and design. Over half of these points are associated with mechanical, electrical, and plumbing systems.

Data Collection and Refinement

With the help of the engineering interns, each district entered the necessary school and utility information into the online *SchoolDude's UtilityDirect* service. The intern then exported the entire data set into a comma delimited file (.csv). Each file typically contained two years of monthly data for each building meter including: building identity, building type, utility/meter identity, billing period, utility type, units of consumption, actual demand, billing demand, usage, cost, and others. Utility data for 87 elementary, middle, intermediate, junior-high, and high school campuses were collected. The finalized number of schools evaluated was reduced by three to 84, because two schools were classified as 'alternative schools' and one as a preschool. Four building/campus types were considered: 56 elementary schools (EL), 8 middle schools (MS), 10 junior high schools (JH), and 10 high schools (HS). Each campus or school contained from one to several electricity, natural gas, and water meters. School campuses with multiple meters of the same type were combined. For example, if a school has two electric meters, the sum of the reported monthly consumption was used. Natural gas, electrical demand, and water were treated the in the same manner. This does not add significant error related to consumption and assumes a diversity of one for electrical demand. Review of the data showed that the most recent 12 consecutive months of utility data occurred May 2004 – April 2005. These data were primarily used for the analysis and are presented throughout this report. Many schools had utility data for May and June, while some did not due to the time lag in utility billing. Annual electricity, natural gas, and water consumption and costs are given in Figures 3.1 – 3.6. These figures show that, in general, consumption and costs are greatest in high schools and least in elementary schools. The next section will present the analysis and discussion of the various utility benchmarking parameters.

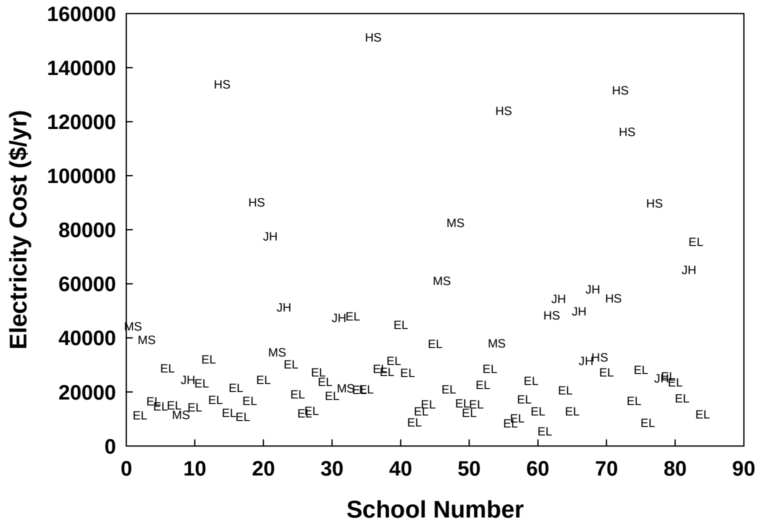


Figure 3.1. Annual electrical cost for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2). HS-high school; JH-junior high; MS-middle school; EL-elementary.

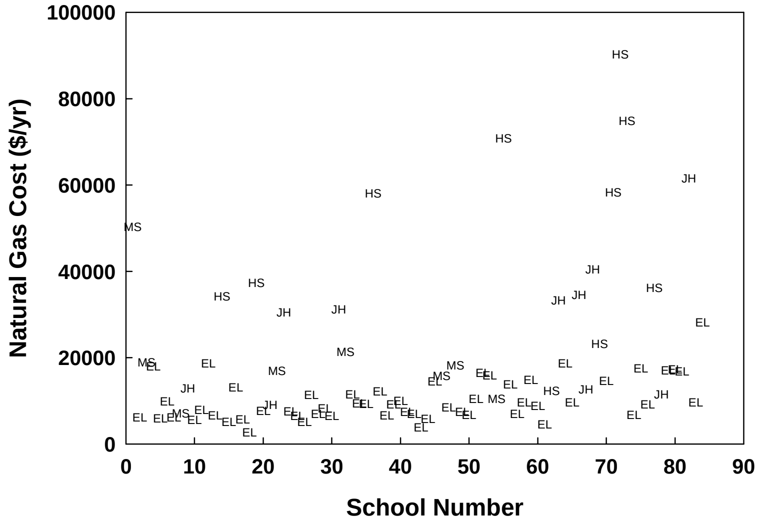


Figure 3.2. Annual natural gas cost for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2). HS-high school; JH-junior high; MS-middle school; EL-elementary.

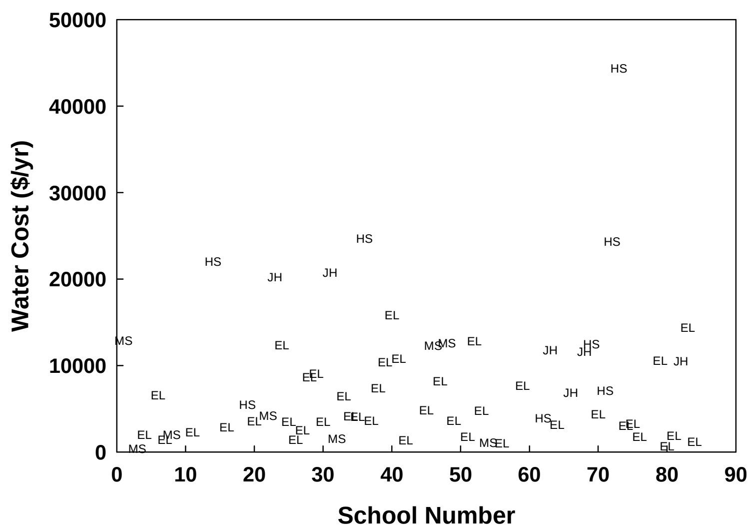


Figure 3.3. Annual water cost for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2). HS-high school; JH-junior high; MS-middle school; EL-elementary.

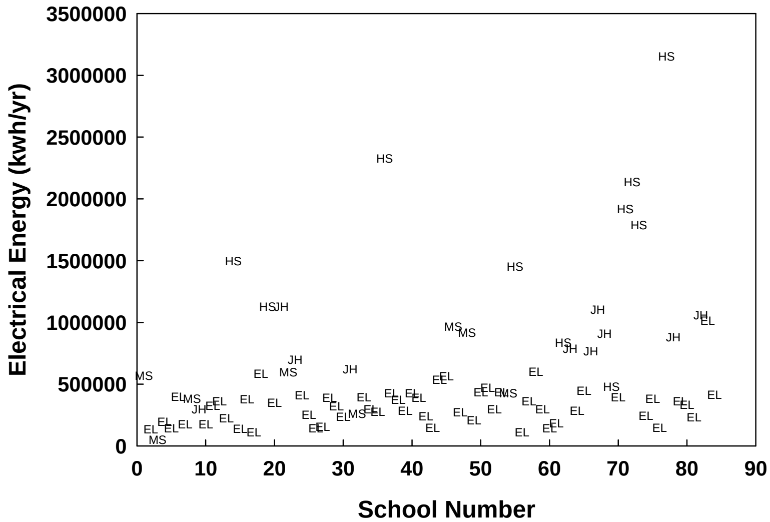


Figure 3.4. Annual electrical consumption for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2). HS-high school; JH-junior high; MS-middle school; EL-elementary.

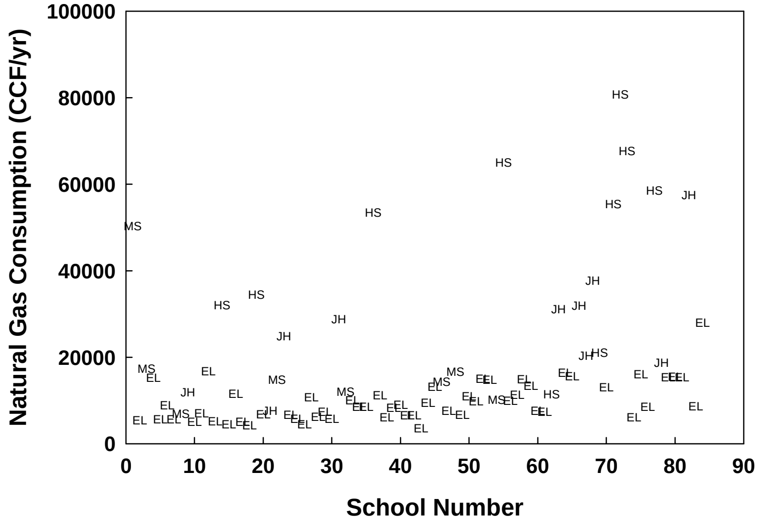


Figure 3.5. Annual natural gas consumption for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2). HS-high school; JH-junior high; MS-middle school; EL-elementary.

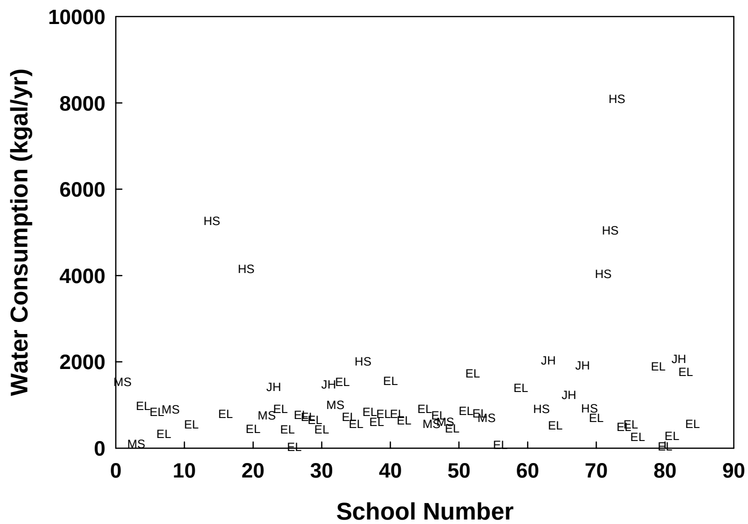


Figure 3.6. Annual water consumption for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2). HS-high school; JH-junior high; MS-middle school; EL-elementary.

Benchmarking Results and Discussion

Plots of the annualized benchmarking parameters are given in Figures 3.7 – 3.50. To maintain a consistent order for comparisons, the data were generally presented for each school relative from lowest to highest combined electricity and natural gas consumption per unit area (in kBtu/ft^2) or grouped by school district. Discussion of the benchmarking will be discussed below according to five groups: total energy and total utility usage (Figures 3.7 – 3.18), electricity consumption (Figures 19 – 26), natural gas consumption (Figures 27 – 32), water consumption (Figures 33 – 42), and additional electrical data – energy, power, and load factor (Figures 43 – 50). Findings from the study for each group listing are given below. The discussion contains very little speculation as to why schools have high or low benchmarking values, because specific building characteristics are just not known. By benchmark comparisons, it appears that 10-20% of the schools have the potential for significant utility cost reductions; however, a more detailed evaluation of each situation would be required. Therefore, this section will contains primarily the benchmarking parameters and discussion on what typically influences the benchmark values. Also, note that comparison of indices that contain dollar values are not easily compared due to utility rate variations and are not a true indicator of building performance. Cost comparisons may be useful at the district level, but not across the state from district to district. In addition, Table 3.1 below shows the average benchmarking values broken out for the four school types.

Table 3.1. Overall average benchmark values for electricity, natural gas, and water consumption for each school type.

School	Average Electricity Benchmarking Parameters			
Type	kwh/ft^2	kwh/student	\$/ft^2	\$/student
EL	6.94	876	0.467	58.5
MS	6.44	958	0.504	72.7
JH	7.64	1234	0.434	71.1
HS	8.06	1437	0.474	85.2

School	Average Electrical Power Benchmarking Parameters	
Type	Load Factor	watts/ft^2
EL	0.27	4.17
MS	0.27	4.67
JH	0.33	3.57
HS	0.36	3.60

	Average Natural Gas Benchmarking Parameters			
	CCF/ft^2	CCF/student	\$/ft^2	\$/student
EL	0.220	28.8	0.232	30.8
MS	0.230	34.4	0.261	38.0
JH	0.246	42.0	0.247	42.7
HS	0.232	41.1	0.243	42.8

	Average Water Benchmarking Parameters			
	kgal/ft^2	kgal/student	\$/ft^2	\$/student
EL	0.016	1.94	0.115	14.0
MS	0.011	1.53	0.069	11.1
JH	0.014	2.51	0.113	20.9
HS	0.019	3.34	0.096	16.7

Total energy and total utility usage (Figures 3.7 – 3.18)
UNITS: kBtu/ft^2, kBtu/student, \$/ft^2, \$/student

These figures are basically informational with only a little indication of specific issues or excessive use because they combine either two (electricity and natural gas) or three (electricity, natural gas, and water) utility types. The extreme cases at both ends of Figure 3.7 show schools with surprising low and high total energy use. As can be seen in later figures, specific for electricity and natural gas, those schools on the low end consume close to the average amount of natural gas, but less in electricity. Similarly, on the high end, one can see several schools that have relatively high natural gas usage.

Electrical consumption (Figures 3.19 – 3.26)
UNITS: kBtu/ft^2, kBtu/student, \$/ft^2, \$/student

The units of electrical energy are typically measured by utilities in terms of kilowatt-hours (kwh). The values used in this report have been converted (except in Table 3.1) from kilowatt-hours to kBtu for easy comparison with natural gas. The conversion factor is 3.412 kBtu/kwh.

Electrical consumption, per ft^2 and per student in Figures 3.19-3.22, is considerably lower than the reported 1999 CBECS regional averages (for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]). The influence of Texas and Louisiana's additional summertime cooling needs likely increases the regional average. The eight district averages were 24.3 kBtu/ ft^2 and 3390 kBtu/student. Schools with electrical energy benchmark values near or over 30 kBtu/ ft^2 or 4000 kBtu/student have a good potential for utility savings.

District comparisons are shown in the even Figures 3.20, 3.22, 3.24, and 3.26. Elementary schools or middle schools higher than the main group cluster or the high school benchmark value should be evaluated for potential electrical savings. High values of energy use per unit area can indicate inefficient building performance. Furthermore, observation of the plot containing electrical costs shows that Arkansas, in general, has relatively low electricity rates.

Natural gas consumption (Figures 27 – 32)
UNITS: kBtu/ft^2, kBtu/student, \$/ft^2, \$/student

The units of natural gas energy are typically measured by utilities in terms of hundred cubic feet (CCF), thousand cubic feet (MCF), or therms (100,000 Btu). The values used in this report have been converted to kBtu for easy comparison with electricity. Values were converted to kBtu using 1 MCF = 1000 kBtu; 1 CCF = 100 kBtu; and 1 therm = 100 kBtu.

Natural gas consumption, per ft^2 and per student in Figures 3.27-3.30, is considerably higher than the reported 1999 CBECS regional averages (for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]). The influence of Texas and Louisiana's reduced wintertime heating needs likely lowered the regional average; however, there is significant variation in natural gas usage. The eight district averages were 22.5 kBtu/ ft^2 and 3230 kBtu/student. Schools with natural gas energy benchmark values near or over 30 kBtu/ ft^2 or 4000 kBtu/student have a good potential for utility savings. The increased scatter in the district plots (like in Figure 3.28) make is relatively easy to identify specific schools within district that are potentially using excessive natural gas (see high elementary schools in nearly every district). As mentioned earlier, specific reasons why these benchmarks are high has not been determined. These values are simply a first-level evaluation tool for identifying schools with potential to reduce utility costs.

It is well know that natural gas costs have increased significantly over the last several years, so it is no surprise that the natural gas cost benchmark values are higher than those referenced in the plots. However, the district plot, Figure 3.32, again show the large variation in several districts. These variations could be due to more than one utility supplying natural gas, or variation in building equipment. Benchmarking values more closely clustered would indicate overall better building performance and cost benefit.

<u>Water consumption (Figures 33 – 42)</u>
UNITS: kBtu/ft^2, kBtu/student, \$/ft^2, \$/student

In absolute dollars, the amount of money spent on water each year by the school district runs in third place behind electricity and natural gas; however, there appears to be some opportunity for savings. The variation in usage is high with elementary schools in particular, ranging from less than 0.01 to 0.04 kgal/ft^2 consumption. Furthermore, it appears (Figure 3.40) that water costs per gallon vary greatly by district. Smaller districts likely have lower water costs and larger ones located in more highly populated areas.

<u>Additional electrical data – energy, power, and load factor (Figures 43 – 50)</u>
UNITS: kwh/yr, peak kW, watts/ft^2, electrical load factor, kwh/student vs. kwh/ft^2, electrical load factor vs. kwh/ ft^2

In addition to the typical per unit area and per student benchmarks for electricity, additional power-related values were evaluated. These included parameters related to peak power, known as electrical demand. First, the annual electrical energy (kwh/yr) and peak electrical power were evaluated (see Figures 3.43 – 3.44). It is obvious that both total energy and peak power are greatest for the larger facilities like high schools and junior highs. There may be some demand shedding potential as some school approach or exceed 1 MW of electrical power. An evaluation of Figures 3.45 and 3.46 shows at least 3 elementary schools and one middle school with high power requirements. In addition, schools with values approaching or over 4 watts/ft^2 are potential candidates for savings. Figure 3.46 also shows how grouped the watts/ft^2 values can be for a given district and even the state without much influence on location (or likely weather).

Electrical load factor is a dimensionless parameter that incorporates both electrical energy consumption and peak power. In this case the monthly electrical load factor was determined and an annual load factor computed as the average of all twelve months. The load factor is the ratio of actual energy consumption (kwh) divided by the electrical demand multiplied by the number of hours within the given month. In general, load factors for schools should be relatively similar since schools operate generally the same number of hours per month and the buildings operate under similar equipment loads and constraints. This is especially true for similar school types like elementary, middle school, junior high, and high schools. Therefore, buildings with load factors that deviate very far from the average, either above or below, are candidates for potential utility savings. A high load factor indicates the equipment is potentially operating more than necessary (i.e. consuming a high amount of energy, kwh) by possibly operating when the school is closed (weekends, holidays, …). A low load factor is an indicator of too high of peak demand with a potential opportunity for demand shedding or demand-side management. Finally, Figures 3.49 and 3.50 show kwh/student versus kwh/ft^2 and load factor versus kwh/ft^2. Schools well outside the regression line are another way to identify potential candidates for utility savings.

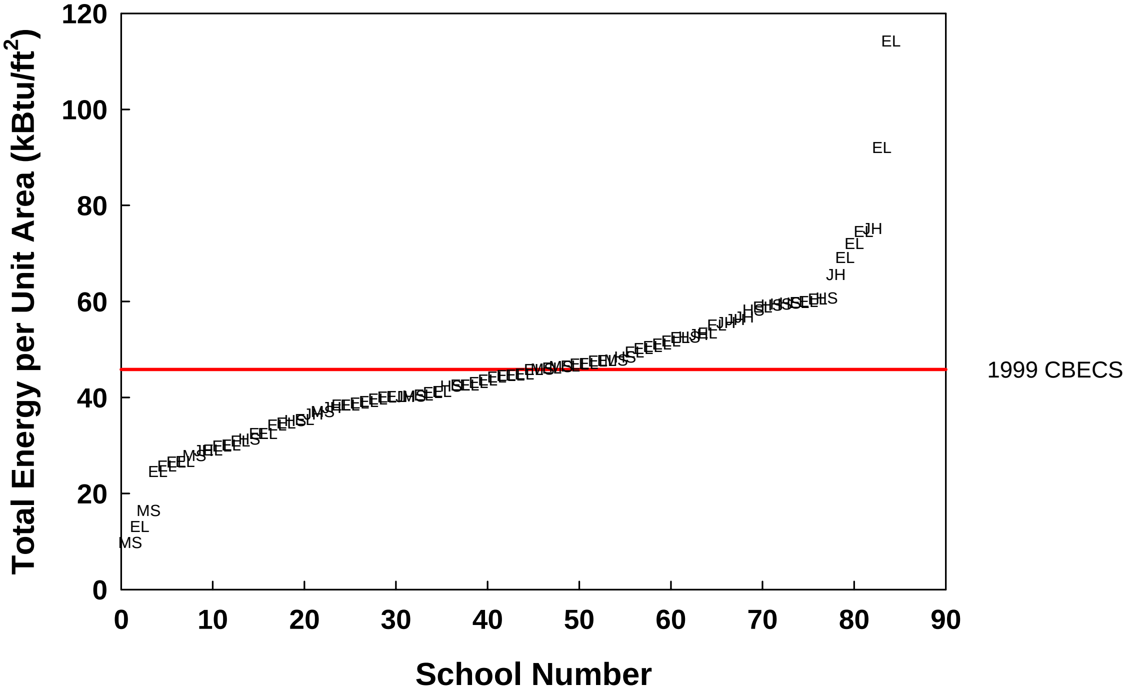


Figure 3.7. Total energy (electricity and natural gas) per unit area for all schools. Reference value is the regional average value for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

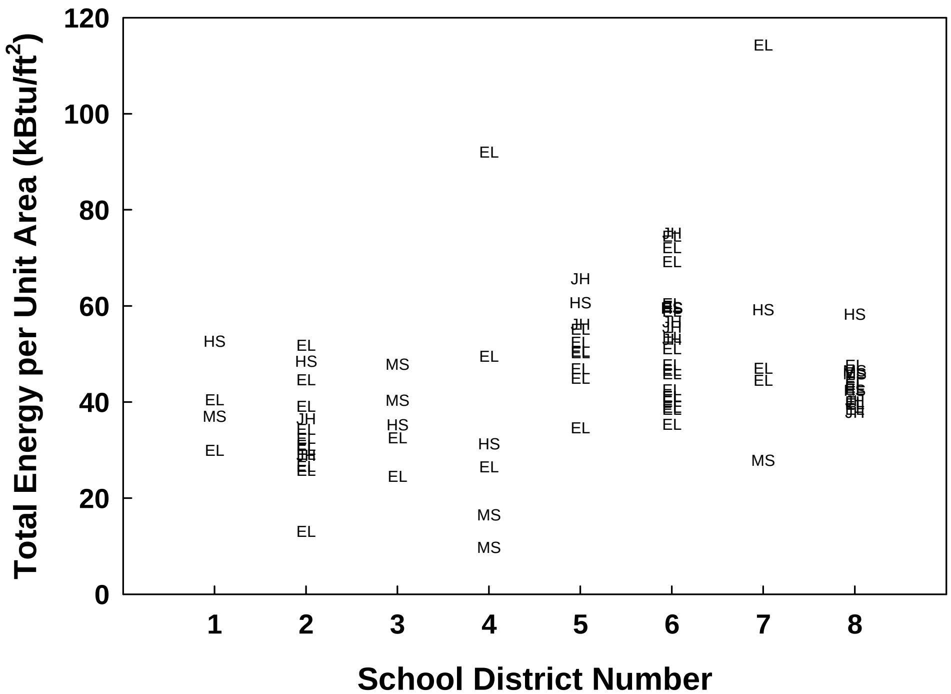


Figure 3.8. Total energy (electricity and natural gas) per unit area for schools within each district. HS-high school; JH-junior high; MS-middle school; EL-elementary.

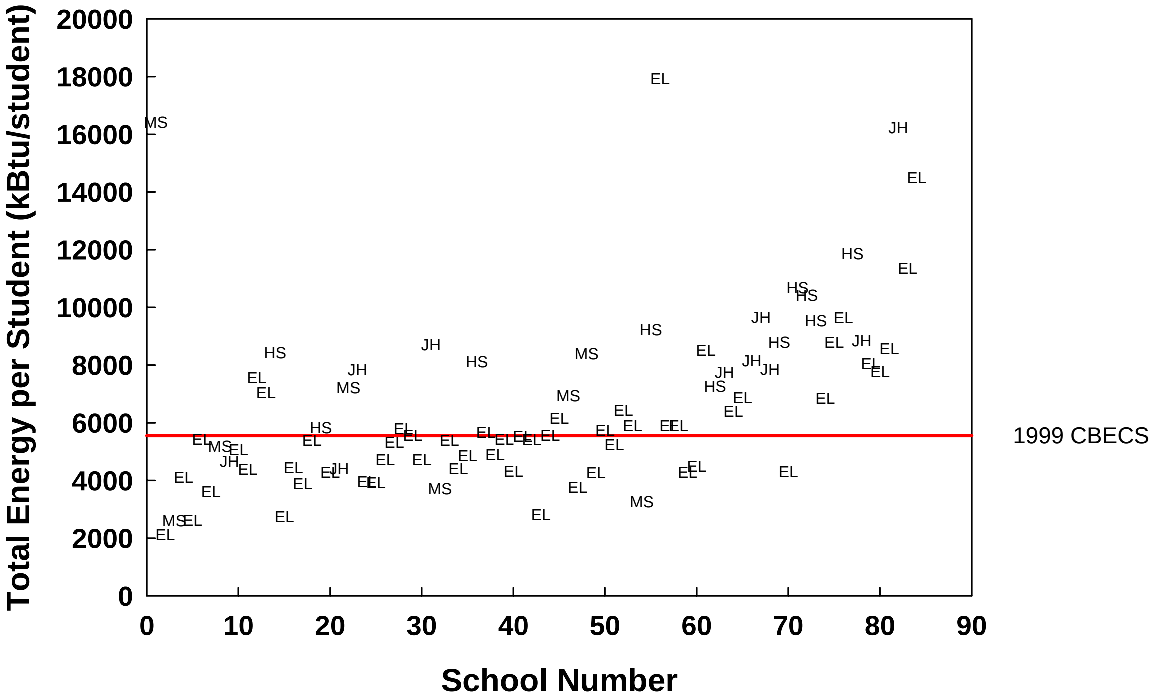


Figure 3.9. Total energy (electricity and natural gas) per student for all schools. Reference value is the regional average value for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

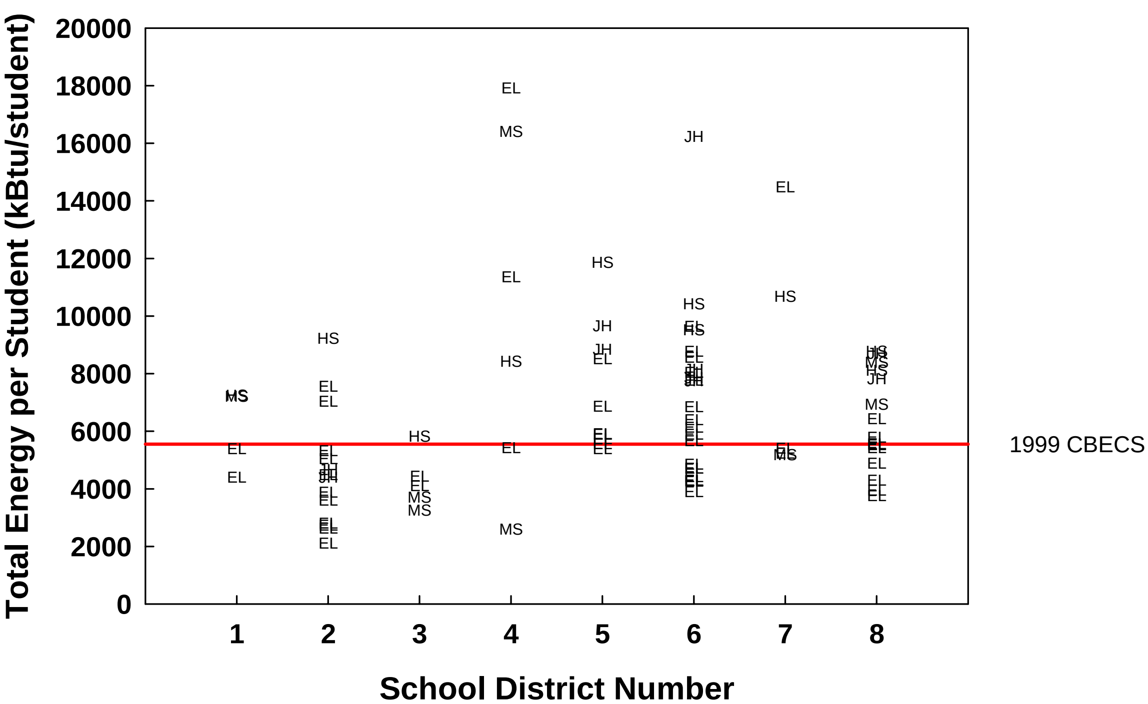


Figure 3.10. Total energy (electricity and natural gas) per student for schools within each district. Reference values is the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

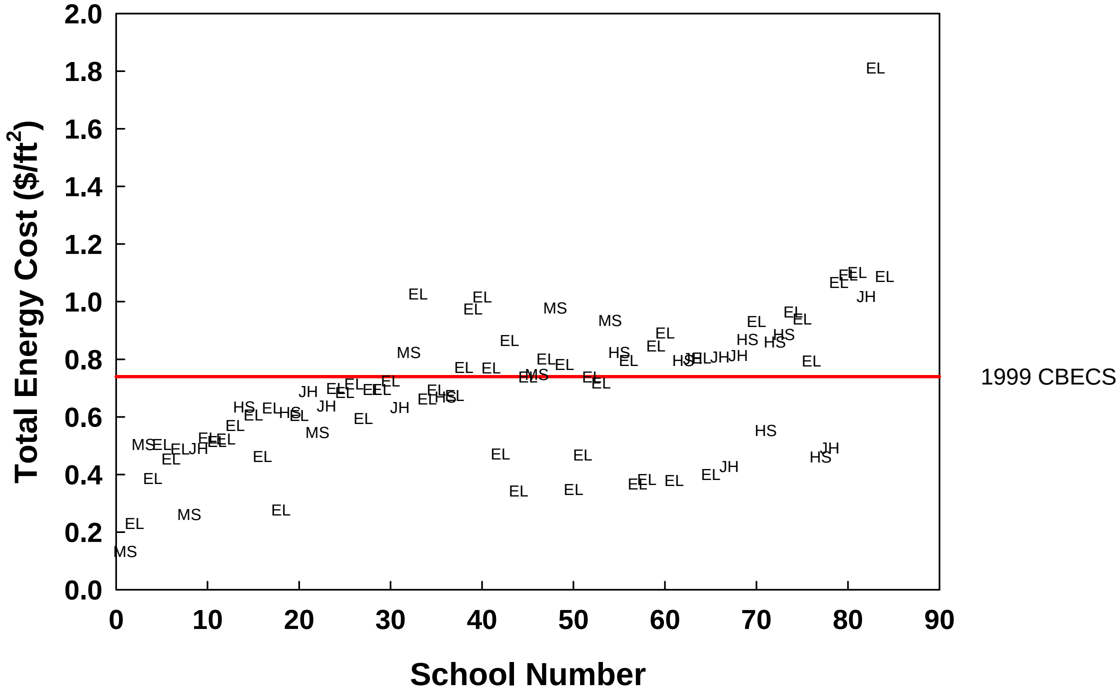


Figure 3.11. Total energy (electricity and natural gas) cost per unit area for all schools. Reference value is the regional average value for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

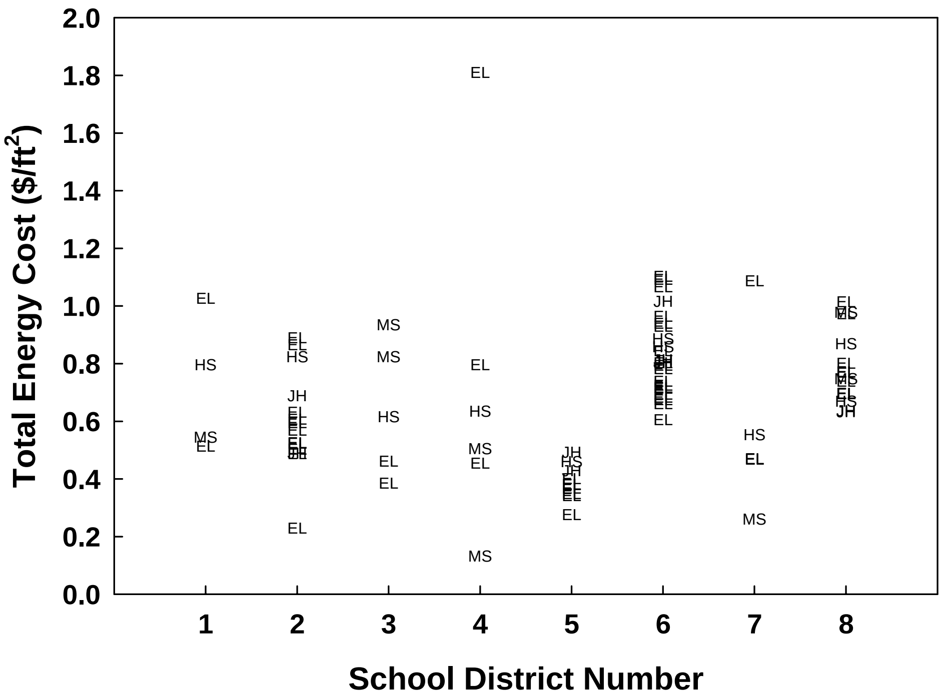


Figure 3.12. Total energy (electricity and natural gas) cost per unit area for schools within each district. HS-high school; JH-junior high; MS-middle school; EL-elementary.

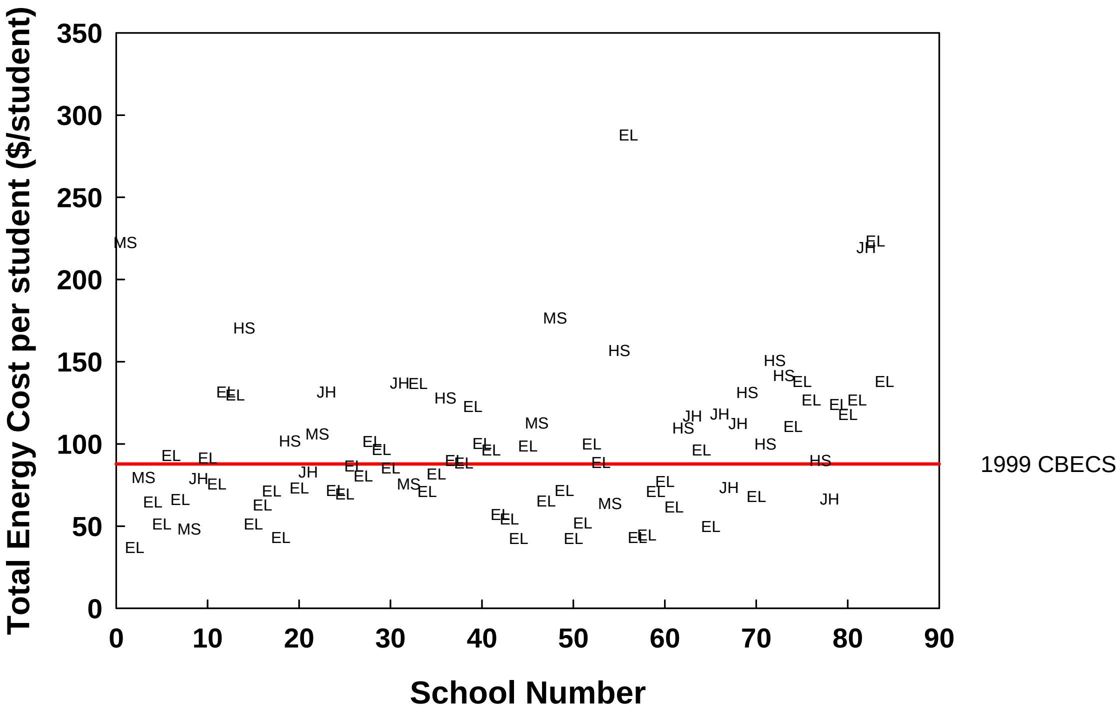


Figure 3.13. Total energy (electricity and natural gas) cost per student for all schools. Reference value is the regional average value for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

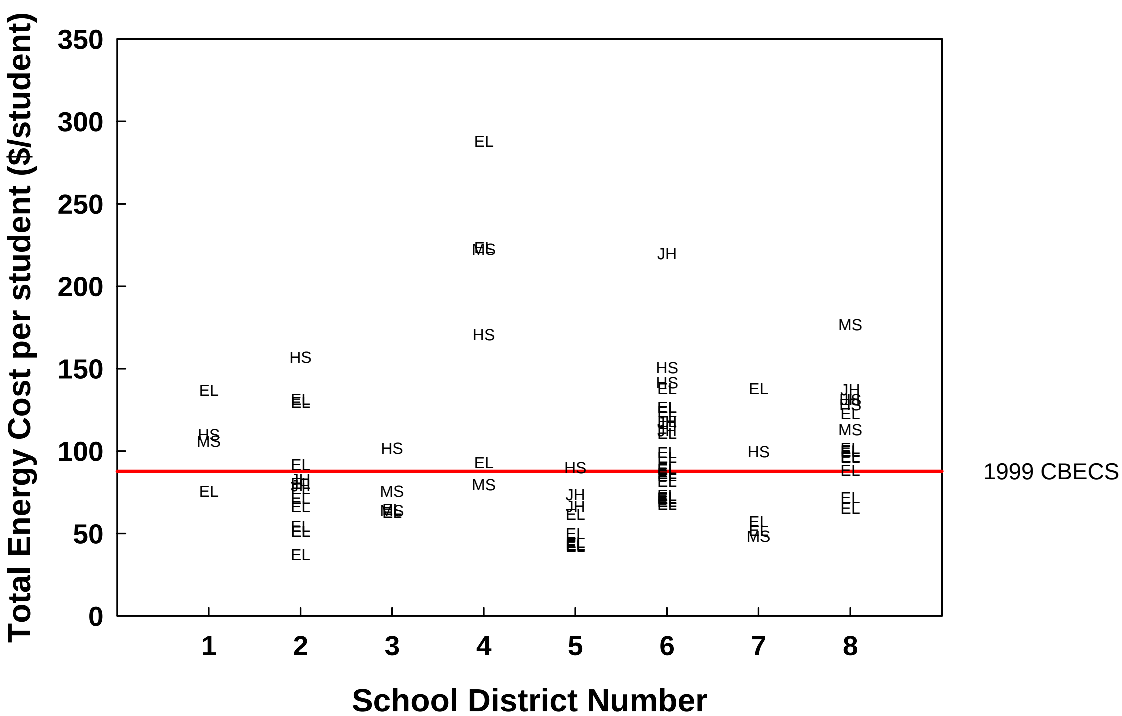


Figure 3.14. Total energy (electricity and natural gas) cost per student for schools within each district. Reference values is the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

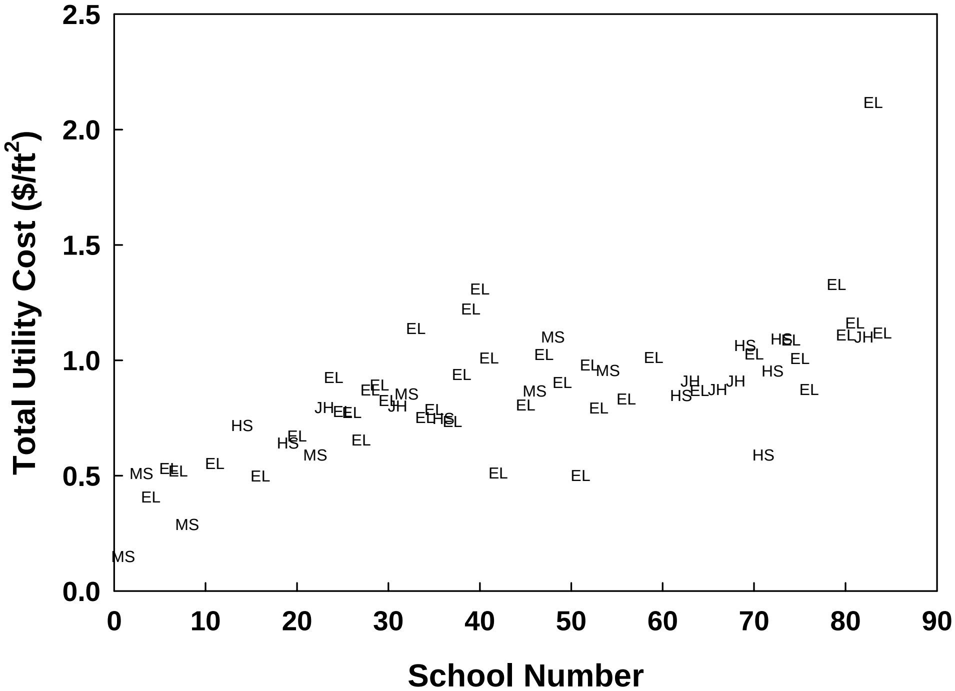


Figure 3.15. Total utility (electricity, natural gas, and water) cost per unit area for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

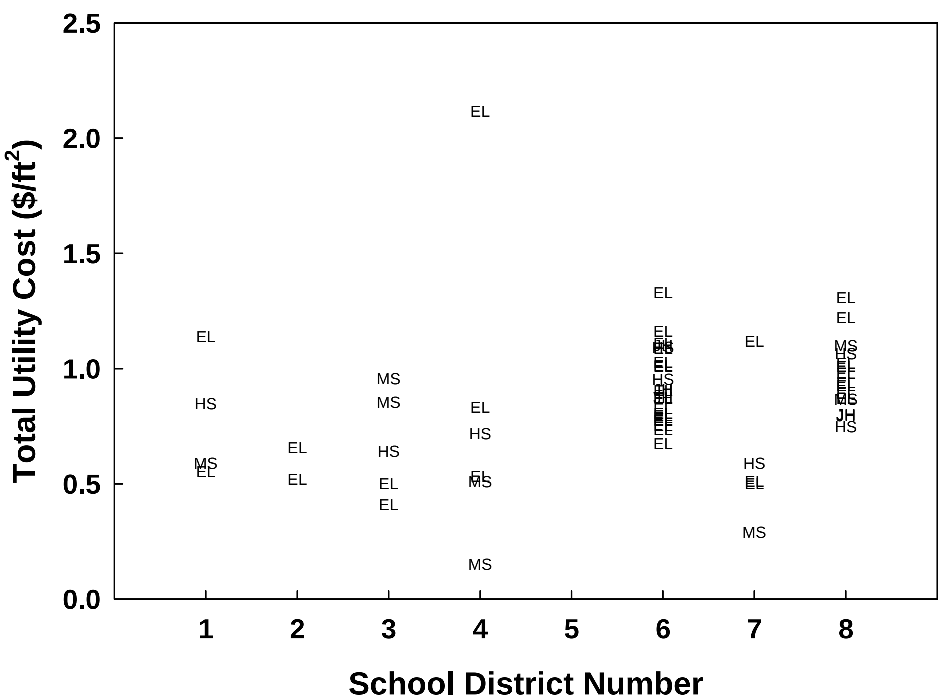


Figure 3.16. Total utility (electricity, natural gas, and water) cost per unit area for schools within each district. HS-high school; JH-junior high; MS-middle school; EL-elementary.

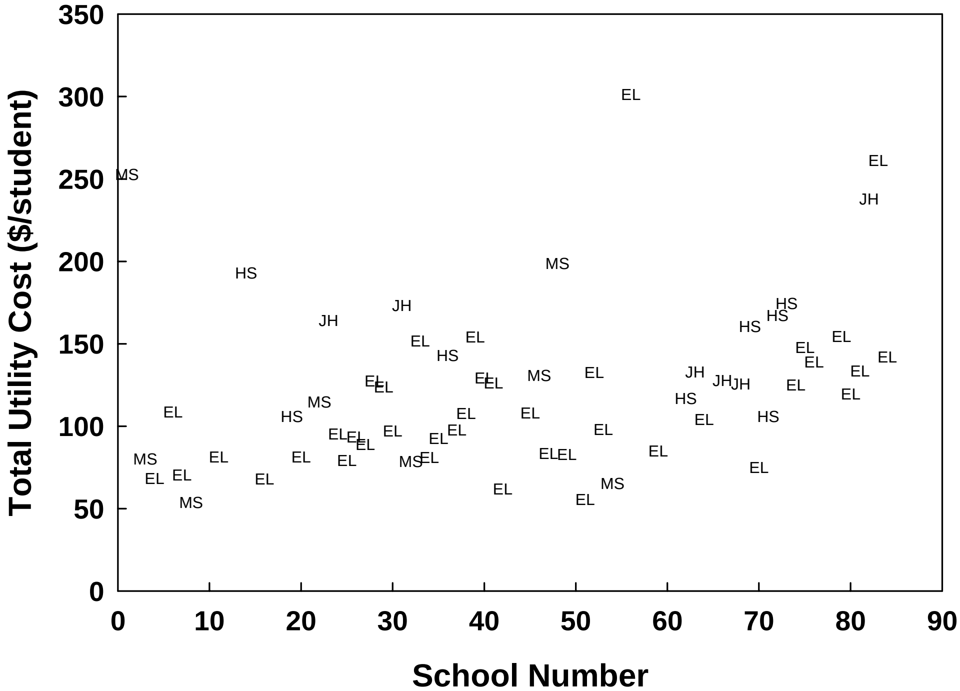


Figure 3.17. Total utility (electricity, natural gas, and water) cost per student for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

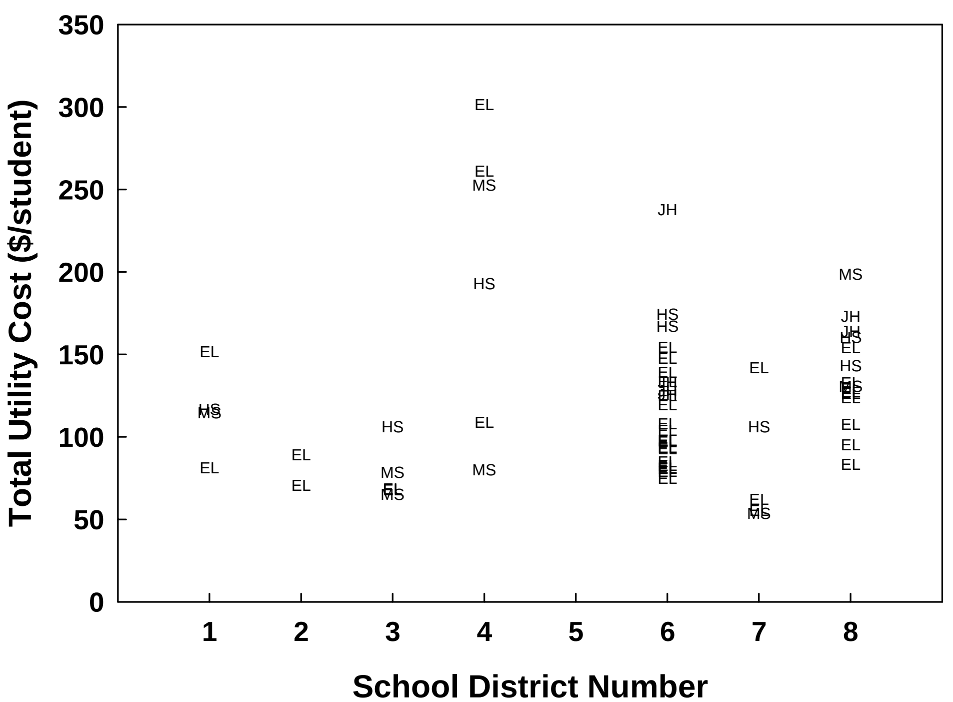


Figure 3.18. Total utility (electricity, natural gas, and water) cost per student for schools within each district. HS-high school; JH-junior high; MS-middle school; EL-elementary.

ELECTRICITY CONSUMPTION

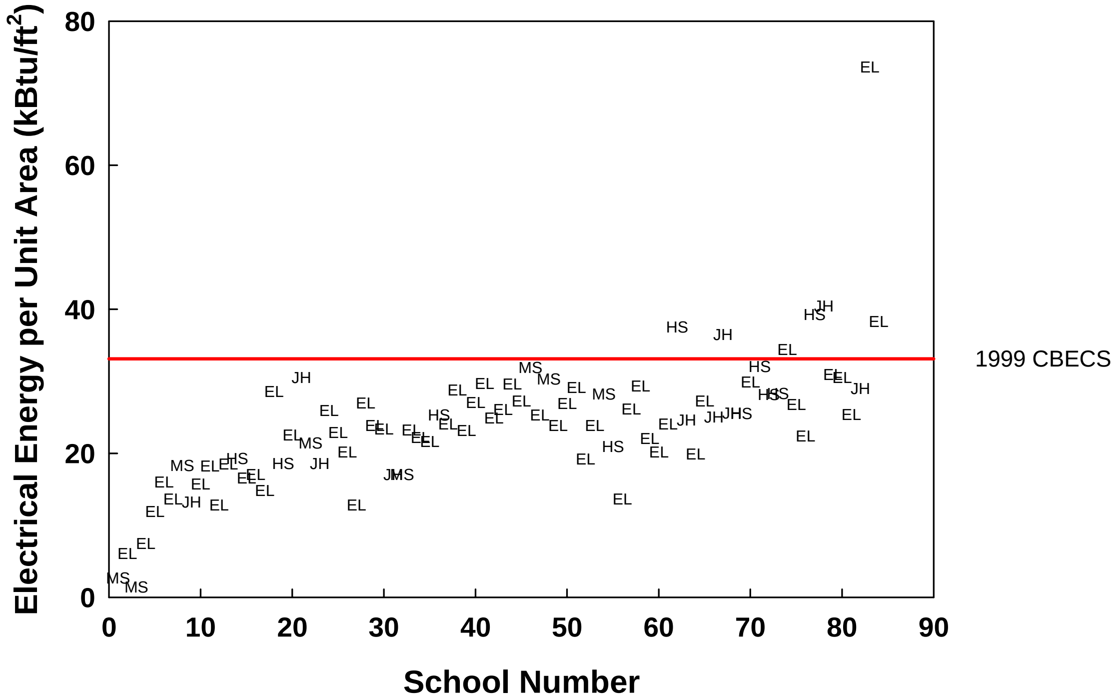


Figure 3.19. Electrical energy consumption per unit area for all schools. Reference value is the regional average value for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

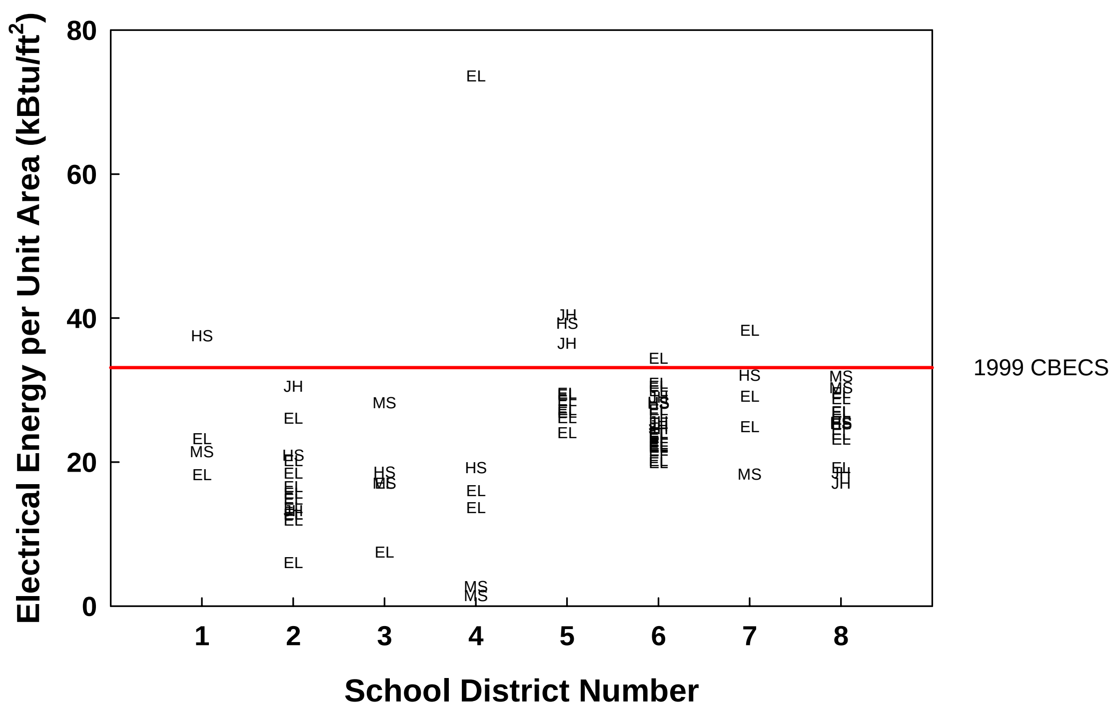


Figure 3.20. Electrical energy consumption per unit area for schools within each district. Reference values is the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

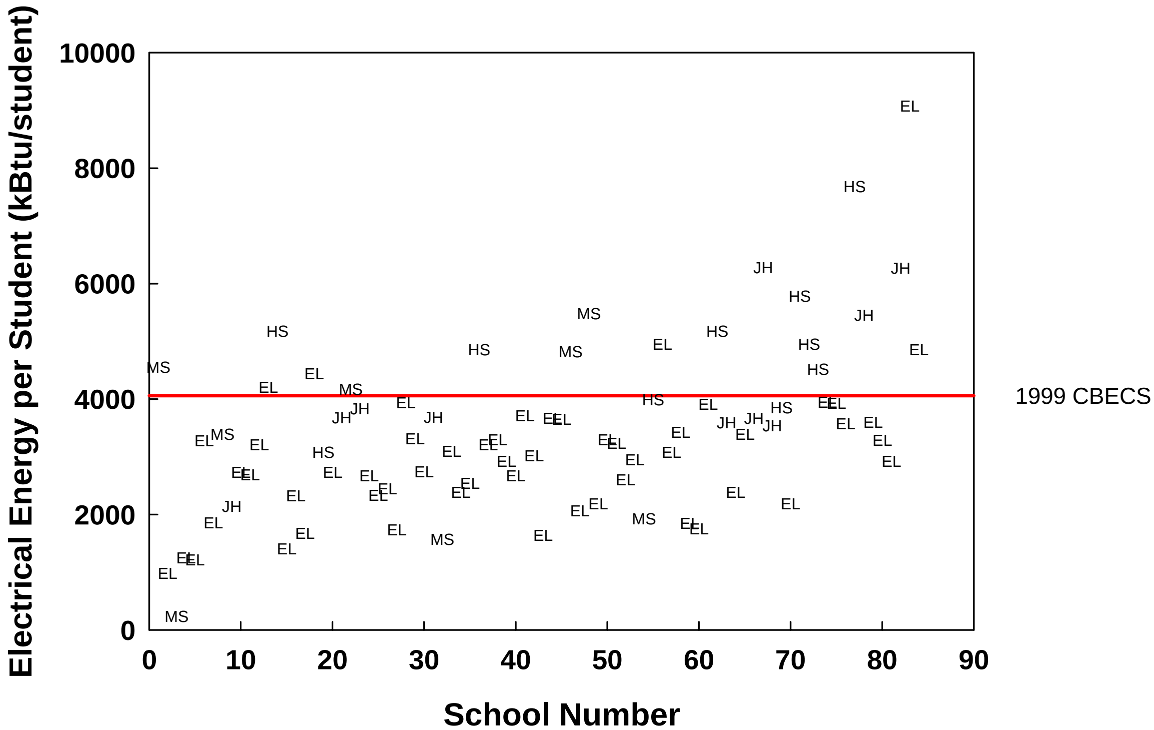


Figure 3.21. Electrical energy consumption per student for all schools. Reference value is the regional average value for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

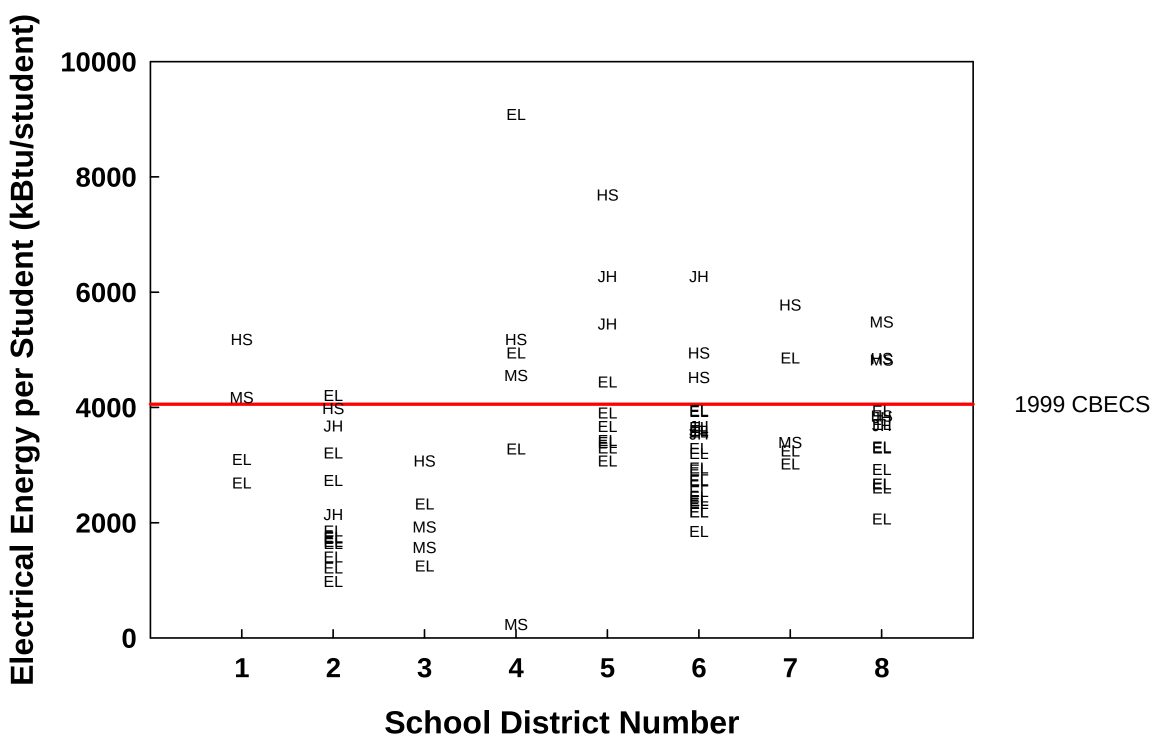


Figure 3.22. Electrical energy consumption per student for schools within each district. Reference values is the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

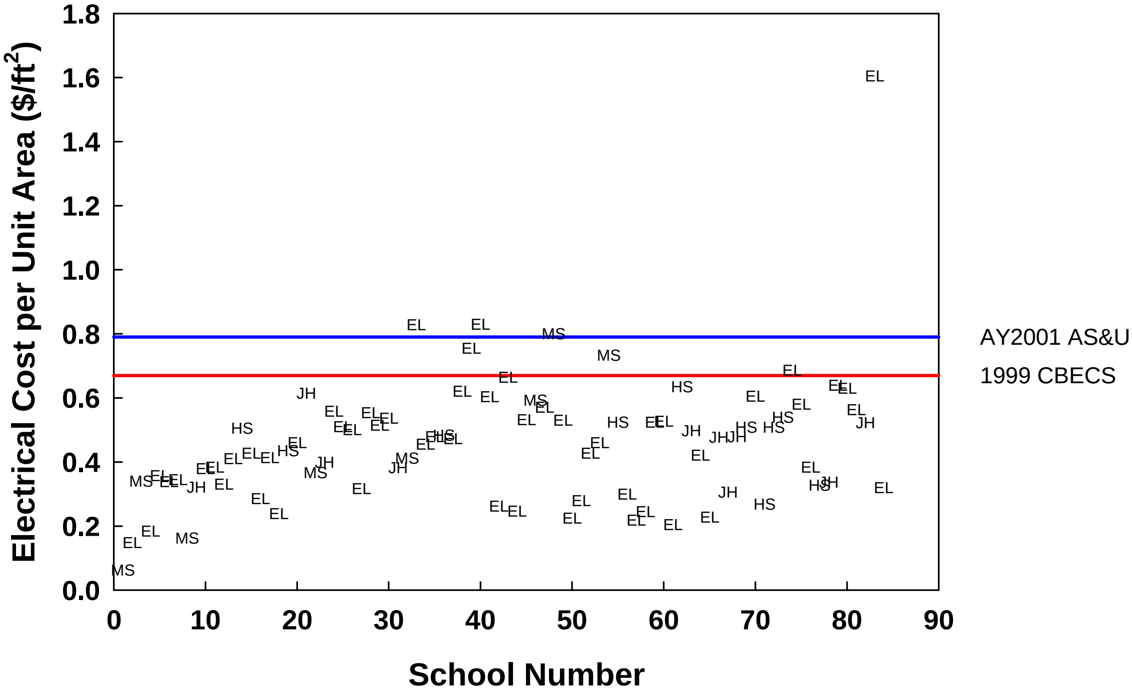


Figure 3.23. Electrical cost per unit area for all schools. Reference values are (in red) the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1] and (in blue) the American School and University survey [9] for K-12 school districts located in the Arkansas, Louisiana, Oklahoma, New Mexico, and Texas region. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

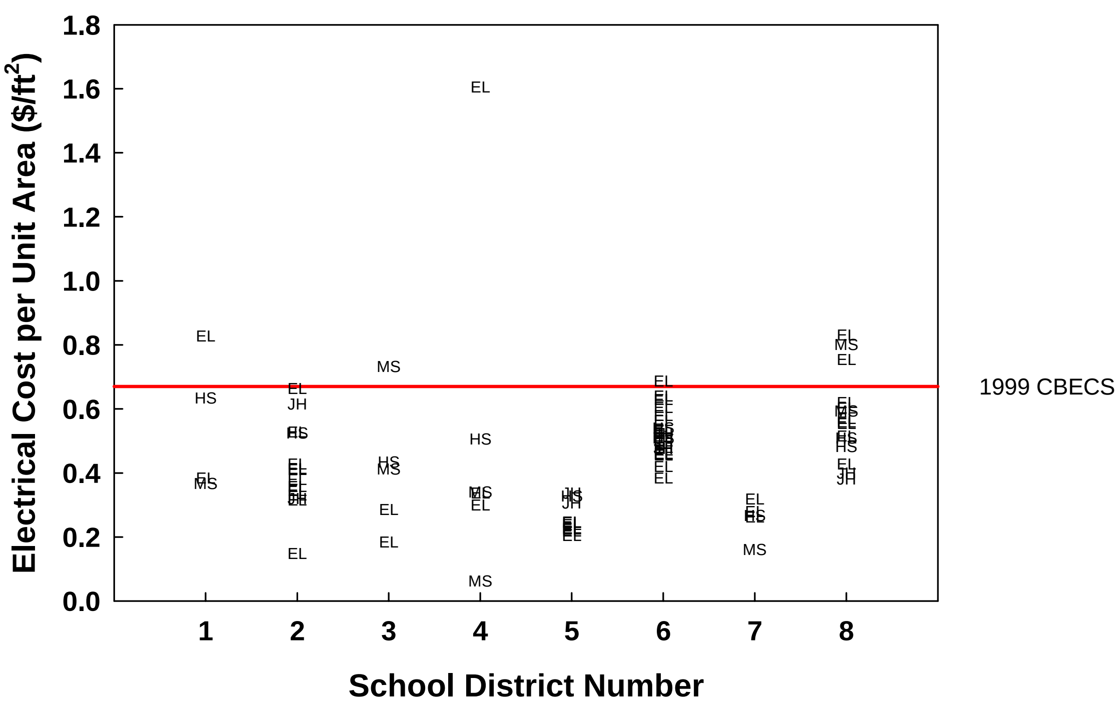


Figure 3.24. Electrical cost per unit area for schools within each district. Reference values is the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

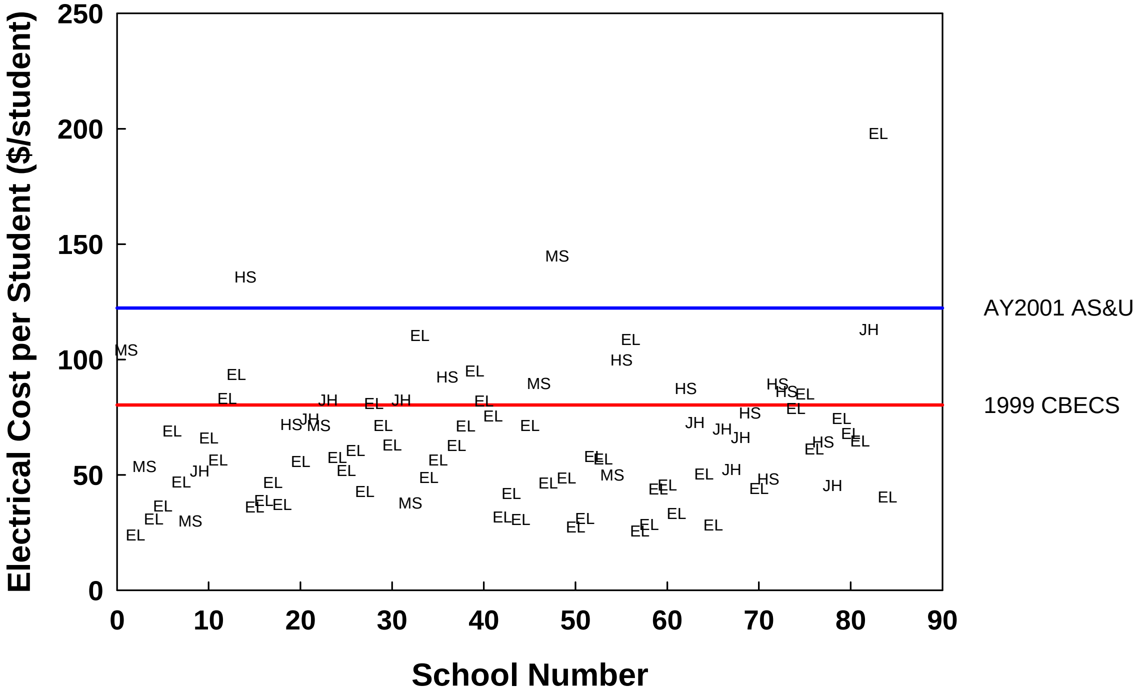


Figure 3.25. Electrical cost per student for all schools. Reference values are (in red) the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1] and (in blue) the American School and University survey [8] for K-12 school districts located in the Arkansas, Louisiana, Oklahoma, New Mexico, and Texas region. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

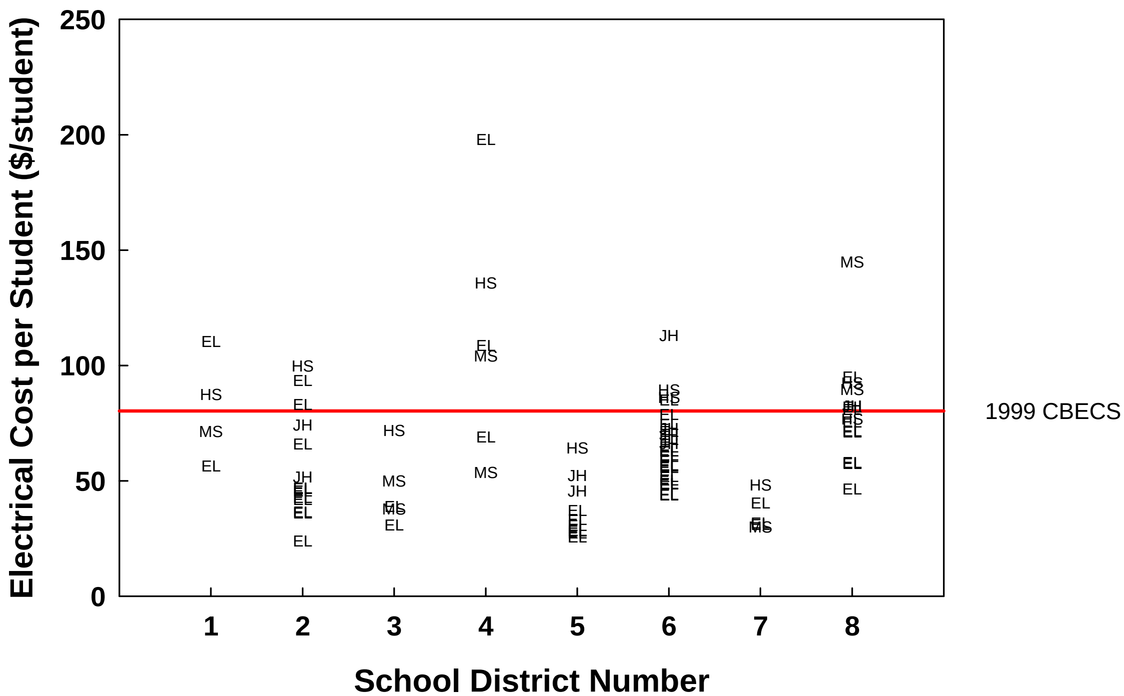


Figure 3.26. Electrical cost per student for schools within each district. Reference values is the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

NATURAL GAS CONSUMPTION

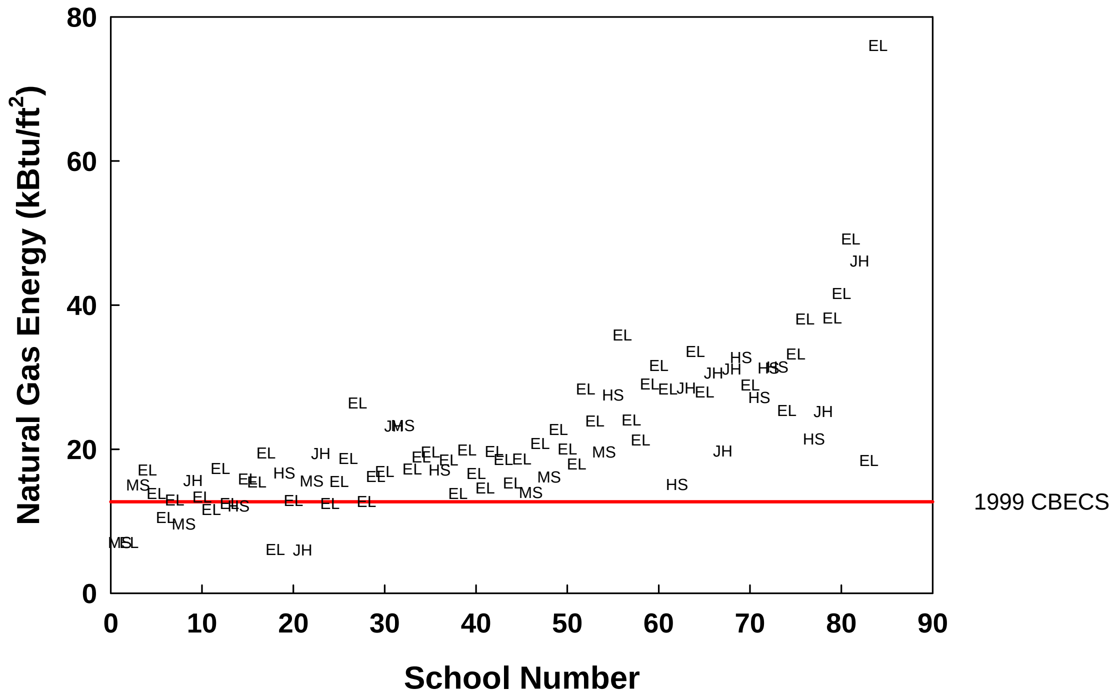


Figure 3.27. Natural gas consumption per unit area for all schools. Reference value is the regional average value for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

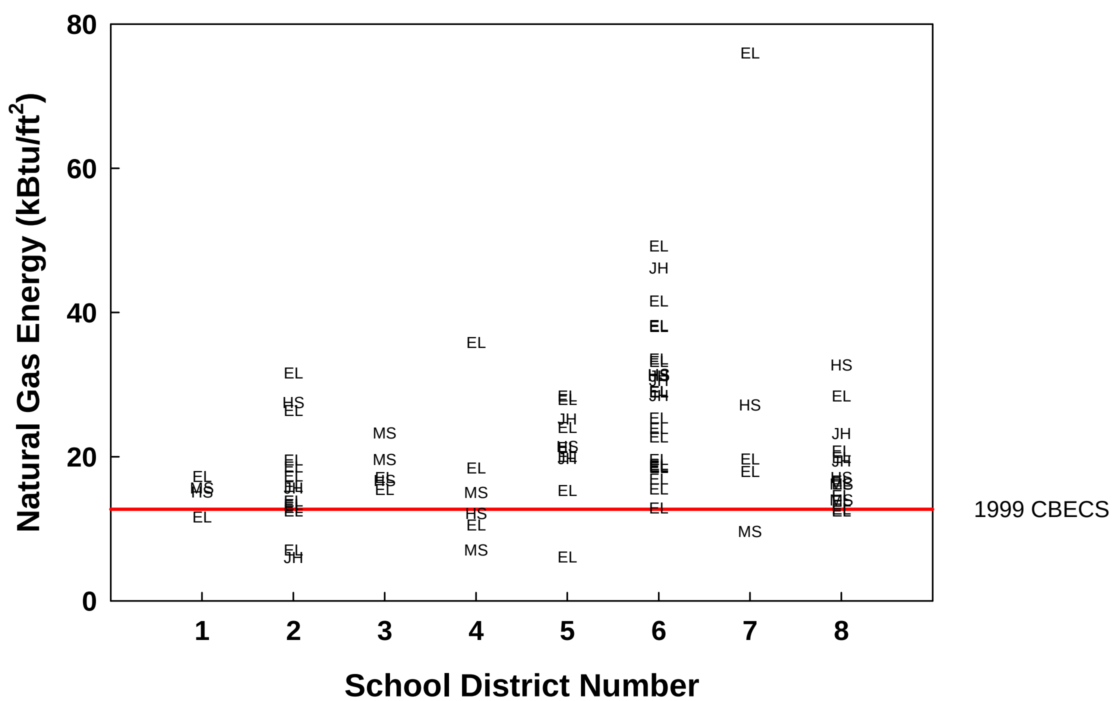


Figure 3.28. Natural gas consumption per unit area for schools within each district. Reference values is the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

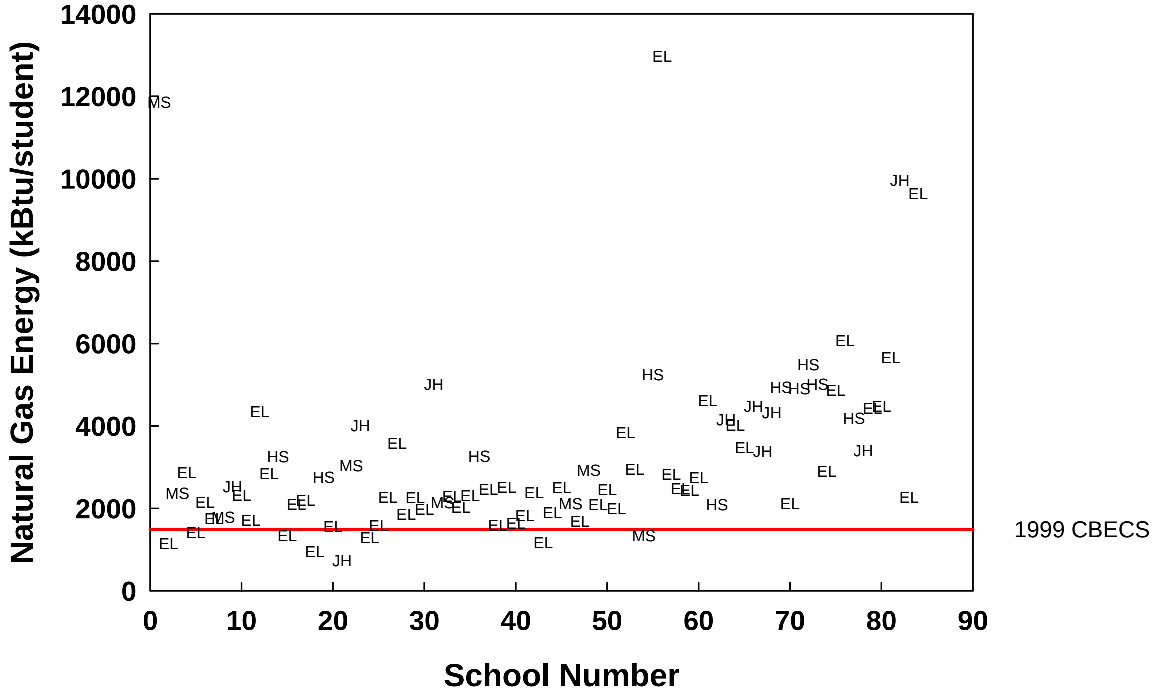


Figure 3.29. Natural gas consumption per student for all schools. Reference value is the regional average value for all K-12 buildings located in Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

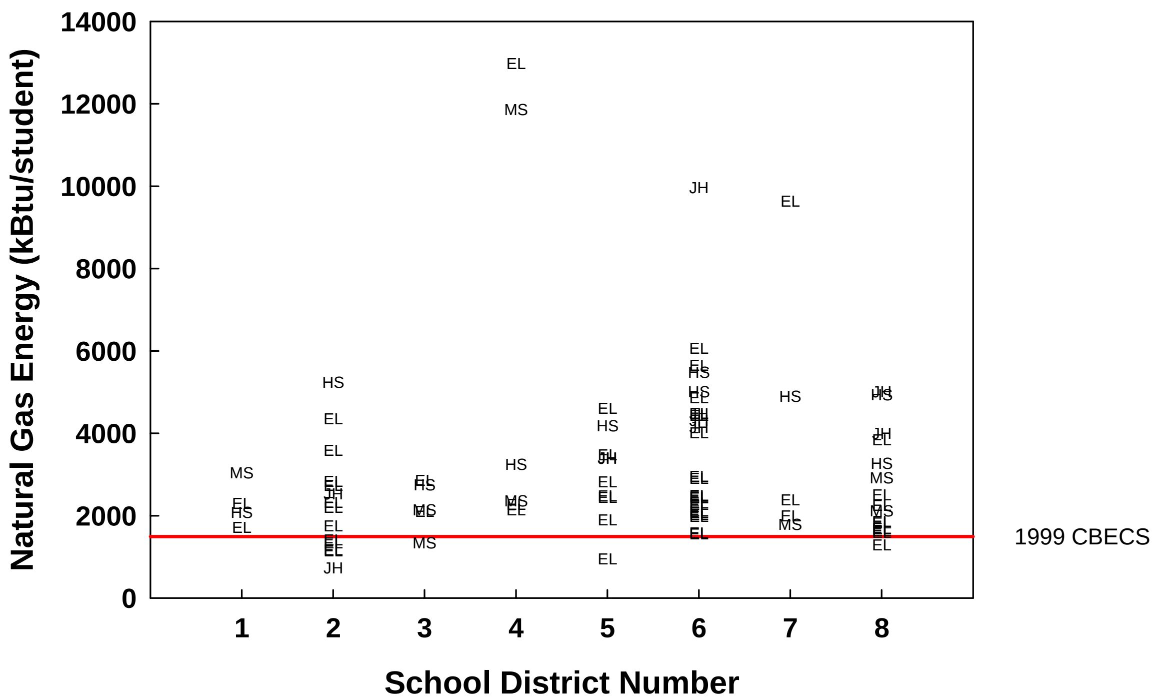


Figure 3.30. Natural gas consumption per student for schools within each district. Reference values is the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

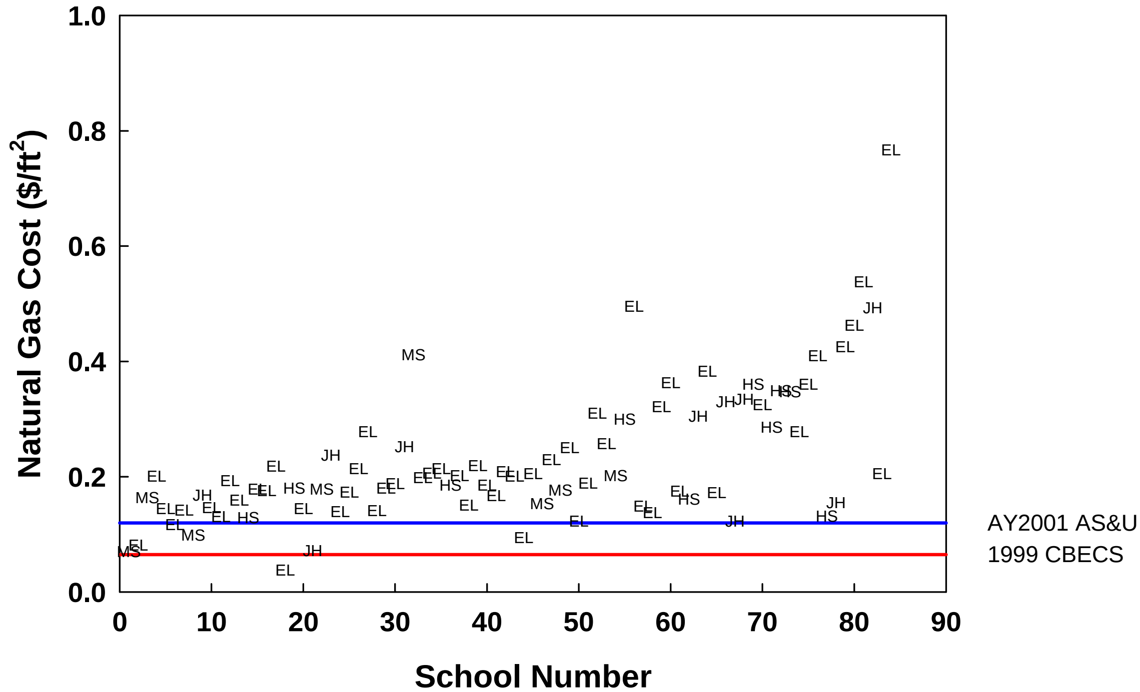


Figure 3.31. Natural gas cost per unit area for all schools. Reference values are (in red) the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1] and (in blue) the American School and University survey [8] for K-12 school districts located in the Arkansas, Louisiana, Oklahoma, New Mexico, and Texas region. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

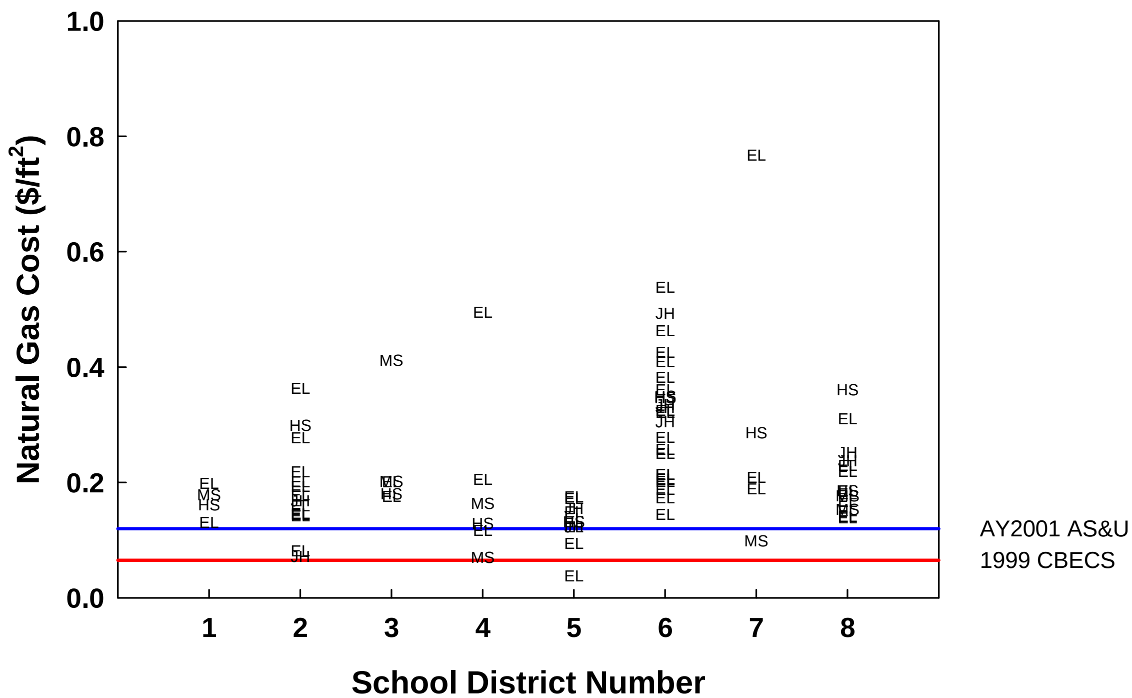


Figure 3.32. Natural gas cost per unit area for schools within each district. Reference values are (in red) the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1] and (in blue) the American School and University survey [8] for K-12 school districts located in the Arkansas, Louisiana, Oklahoma, New Mexico, and Texas region. HS-high school; JH-junior high; MS-middle school; EL-elementary.

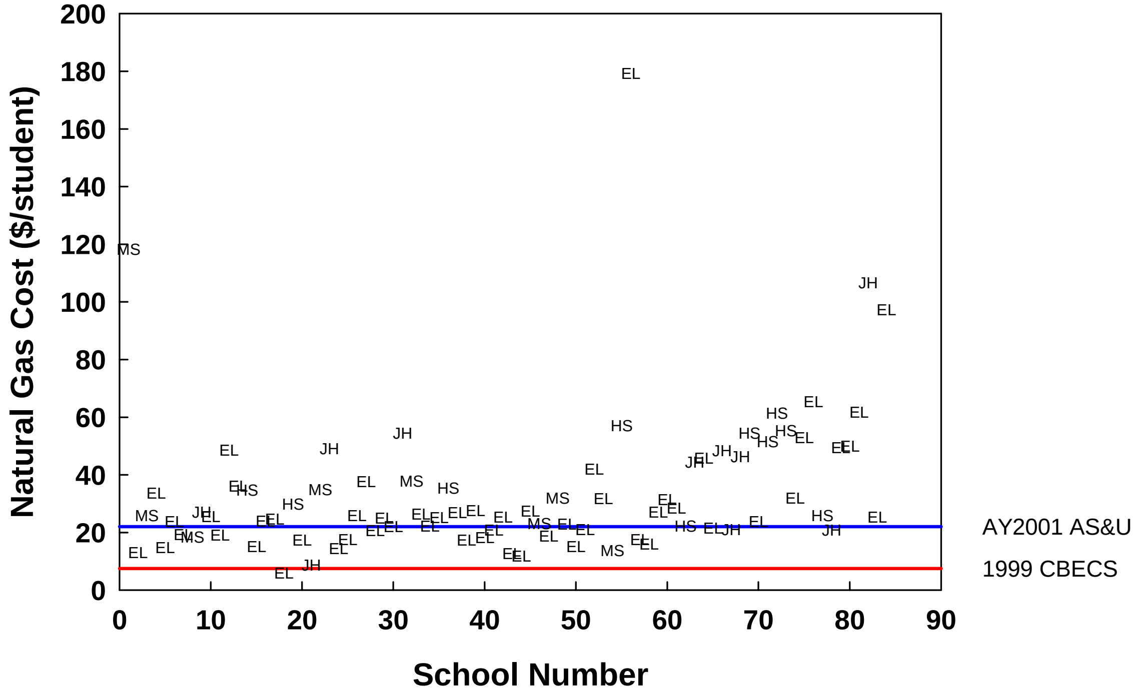


Figure 3.33. Natural gas cost per student for all schools. Reference values are (in red) the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1] and (in blue) the American School and University survey [8] for K-12 school districts located in the Arkansas, Louisiana, Oklahoma, New Mexico, and Texas region. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

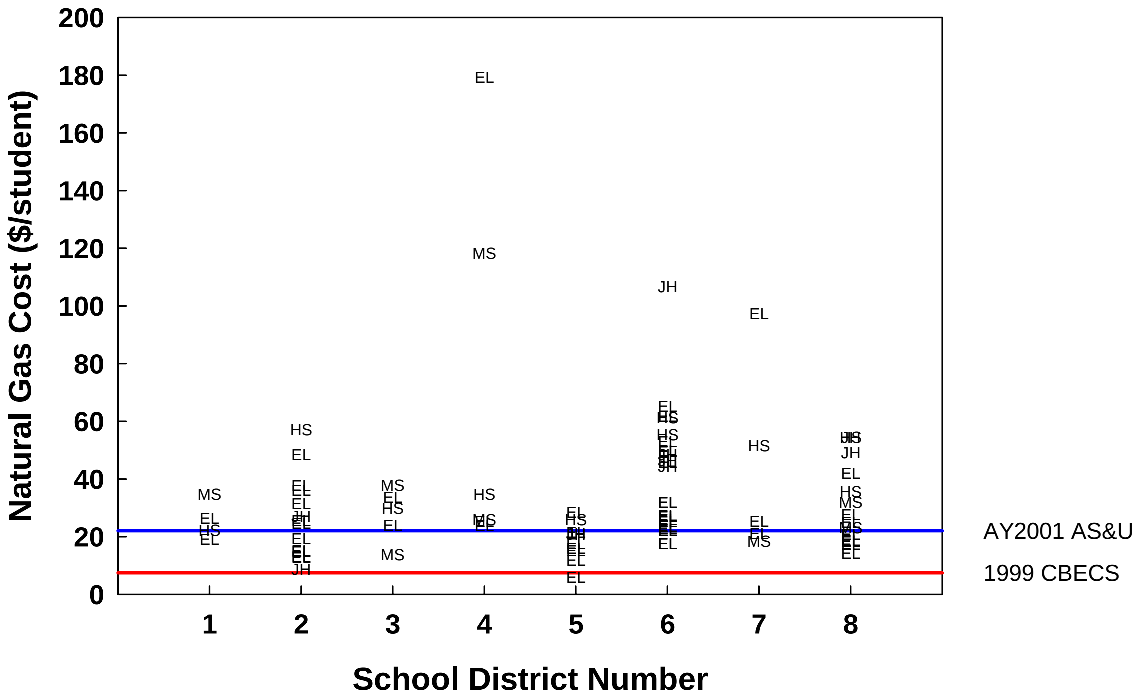


Figure 3.34. Natural gas cost per student for schools within each district. Reference values are (in red) the regional average value for all K-12 buildings located in the Arkansas, Louisiana, Oklahoma, and Texas census division within the 1999 Commercial Building Energy Consumption Survey [1] and (in blue) the American School and University survey [8] for K-12 school districts located in the Arkansas, Louisiana, Oklahoma, New Mexico, and Texas region. HS-high school; JH-junior high; MS-middle school; EL-elementary.

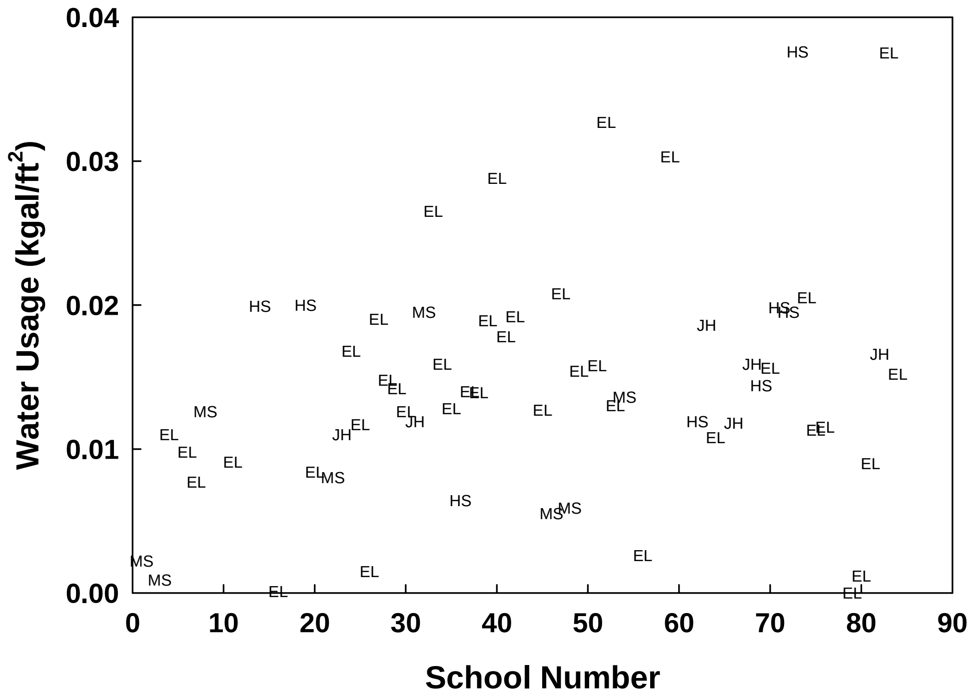


Figure 3.35. Water consumption per unit area for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

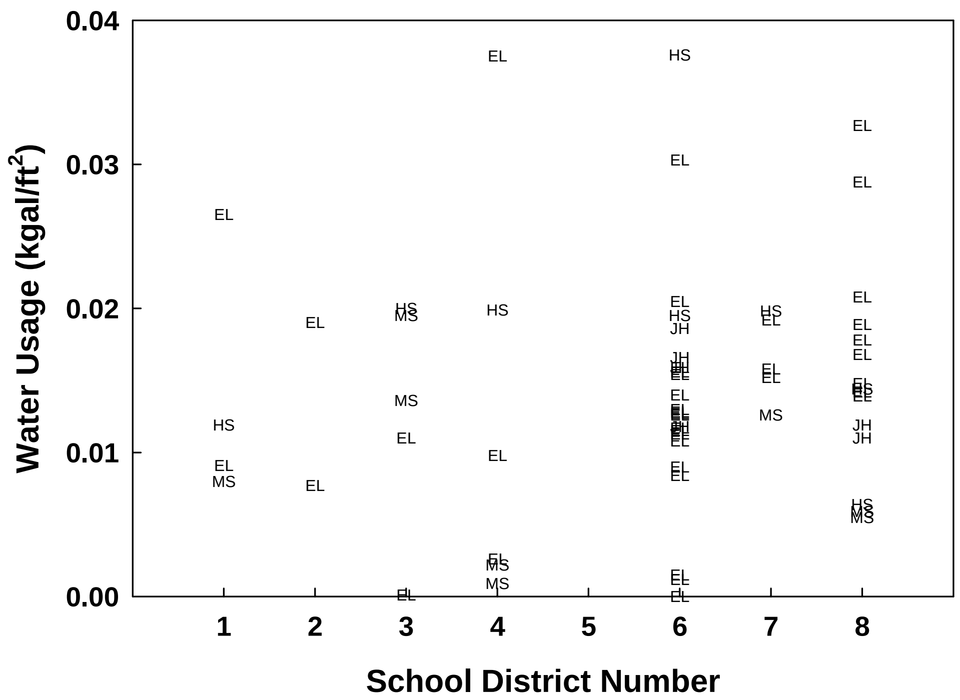


Figure 3.36. Water consumption per unit area for schools within each district. HS-high school; JH-junior high; MS-middle school; EL-elementary.

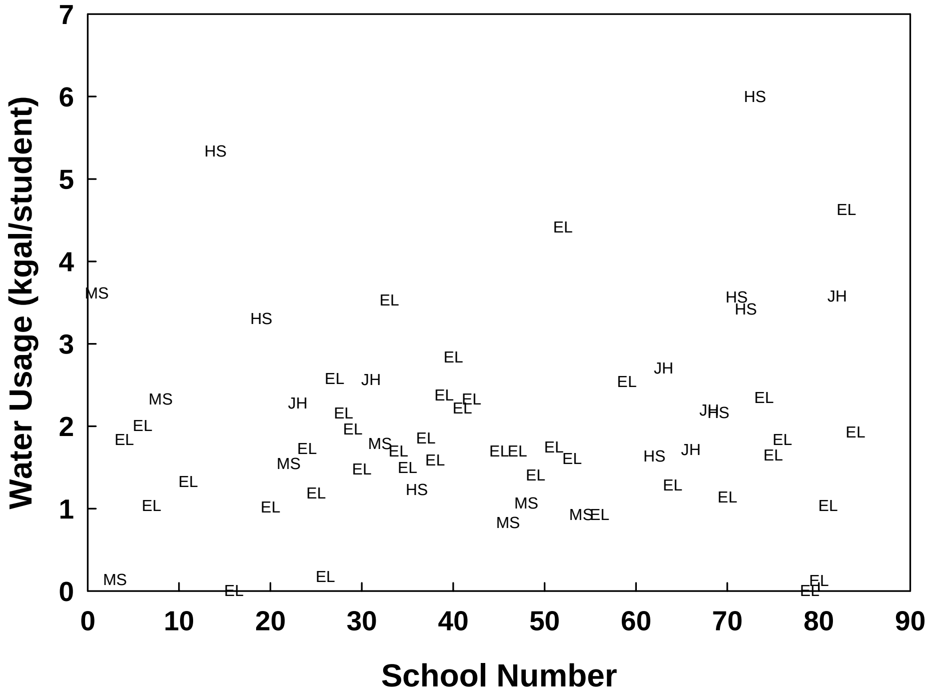


Figure 3.37. Water consumption per student for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

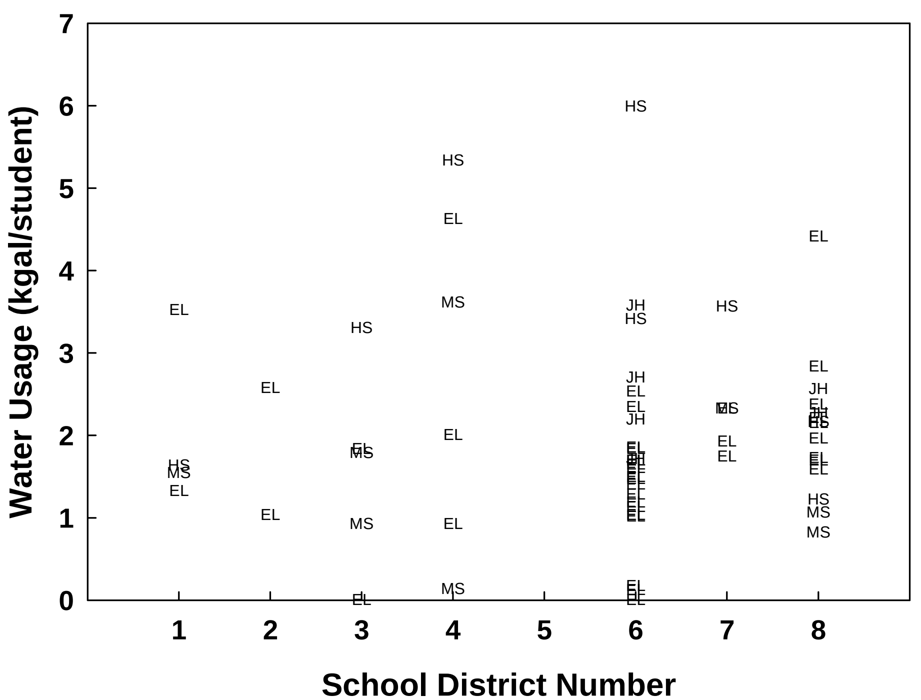


Figure 3.38. Water consumption per student for schools within each district. HS-high school; JH-junior high; MS-middle school; EL-elementary.

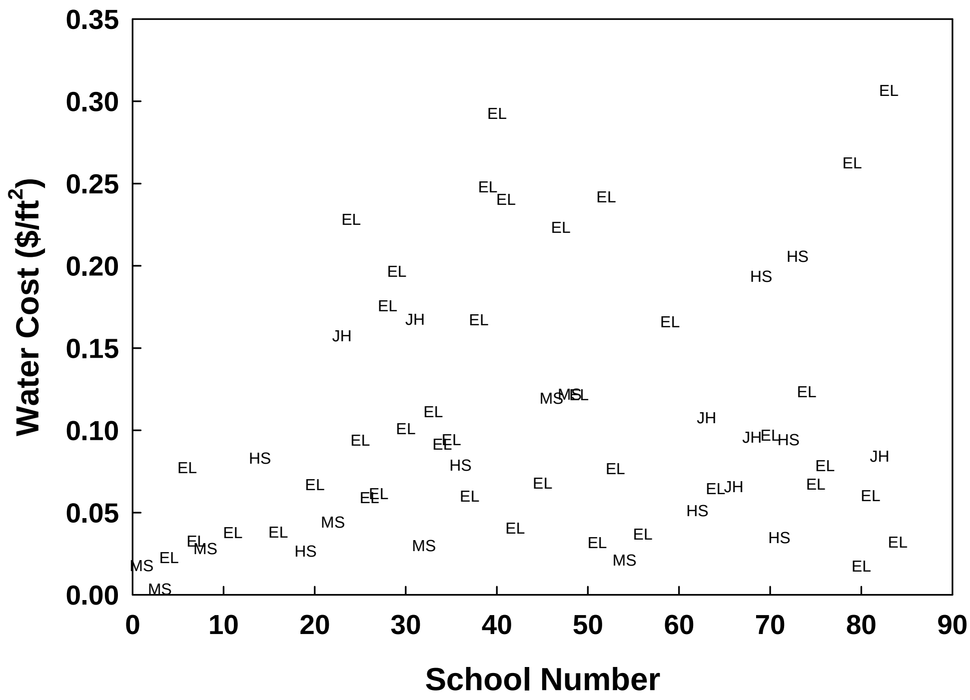


Figure 3.39. Water cost per unit area for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

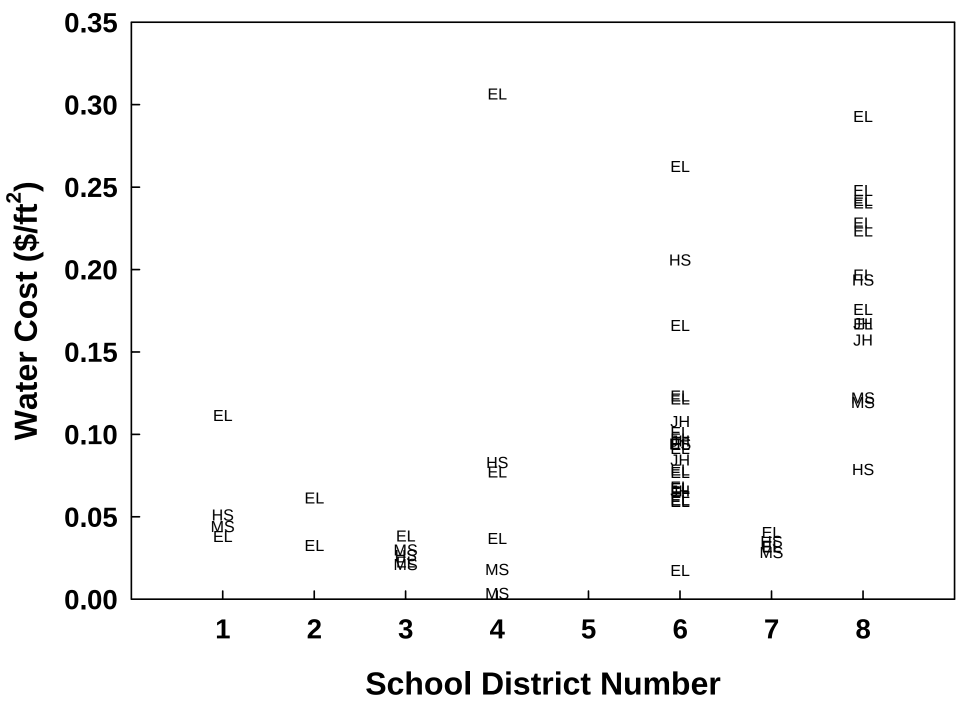


Figure 3.40. Water cost per unit area for schools within each district. HS-high school; JH-junior high; MS-middle school; EL-elementary.

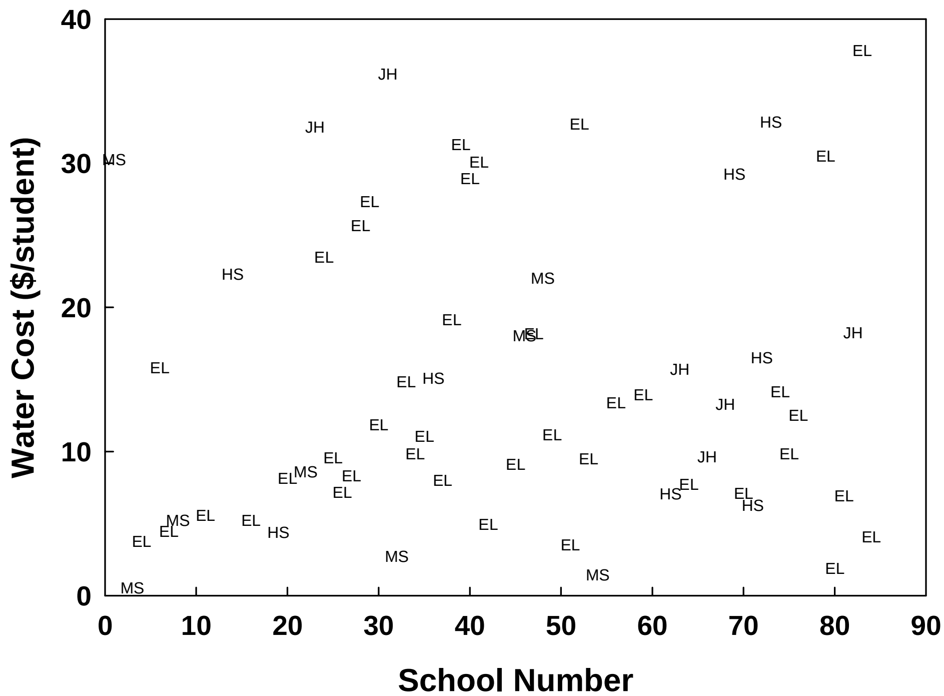


Figure 3.41. Water cost per student for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

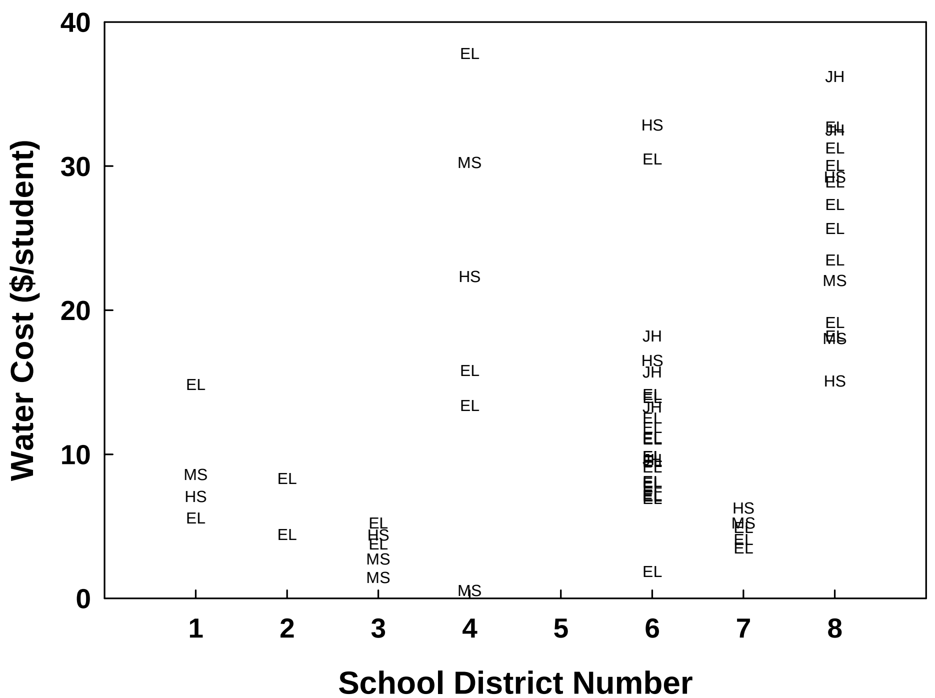


Figure 3.42. Water cost per student for schools within each district. HS-high school; JH-junior high; MS-middle school; EL-elementary.

ADDITIONAL ELECTRICAL DATA (Energy, Power, and Load Factor)

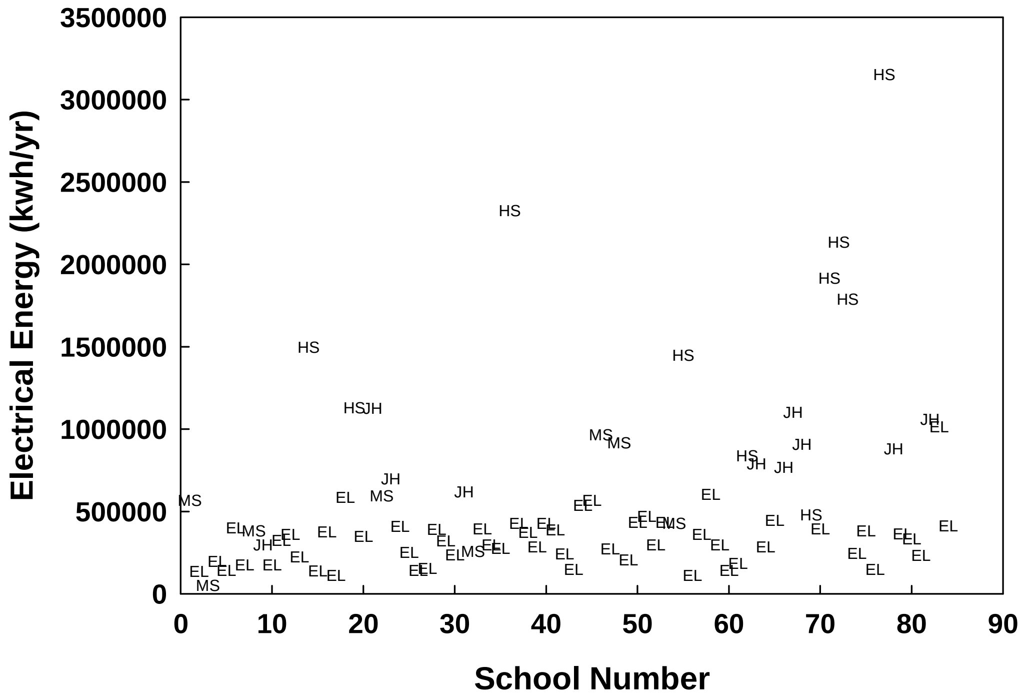


Figure 3.43. Annual electrical energy consumption for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

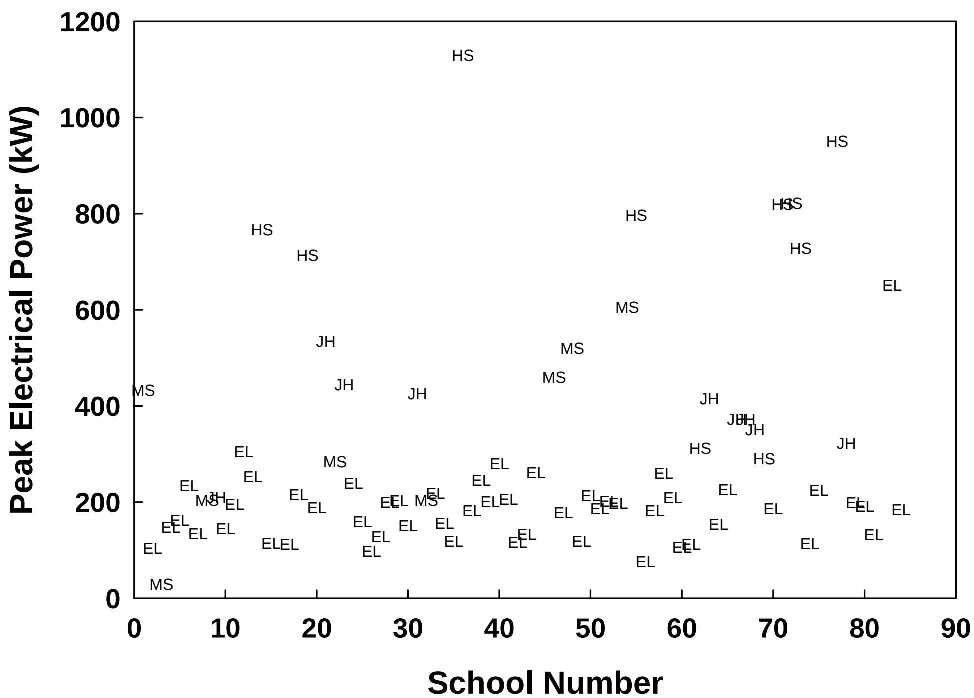


Figure 3.44. Annual peak electrical power for all schools. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

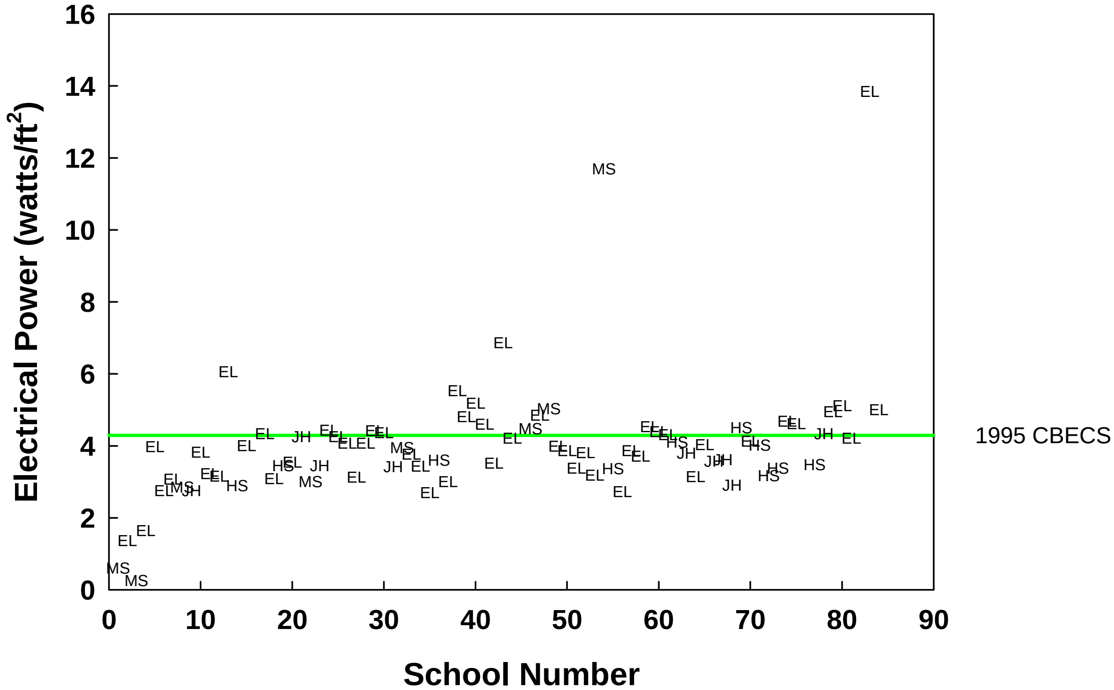


Figure 3.45. Annual peak electrical power required per unit area for all schools. Reference value is the national median value for all educational building types in the 1995 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

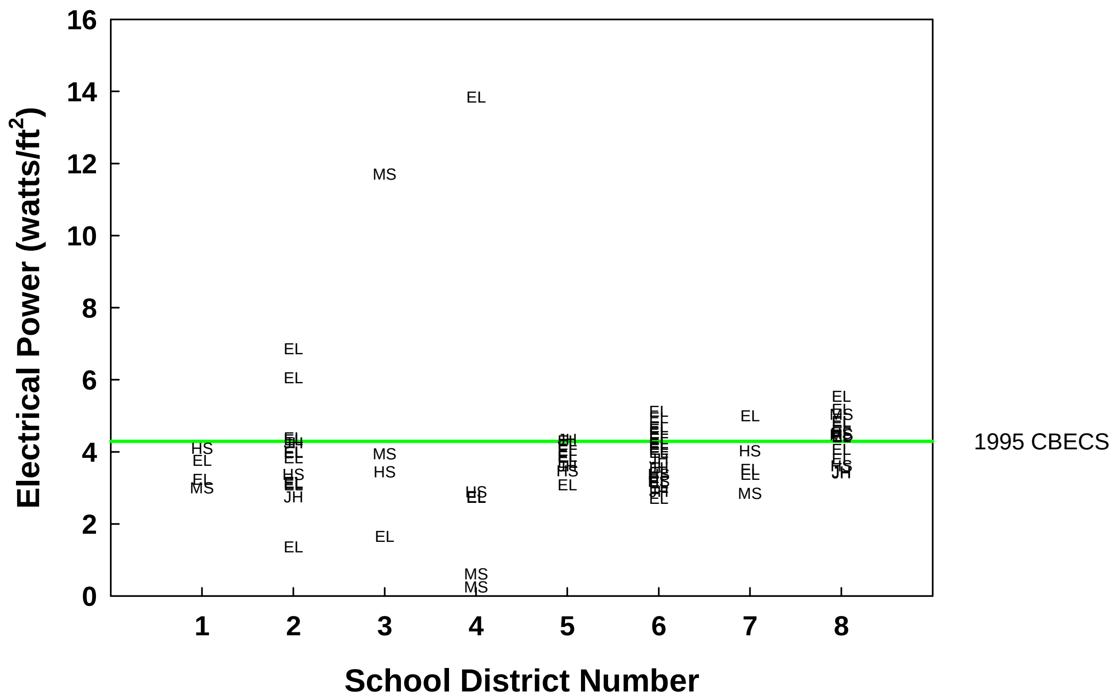


Figure 3.46. Annual peak electrical power required per unit area for schools within each district. Reference value is the national median value for all educational building types in the 1995 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

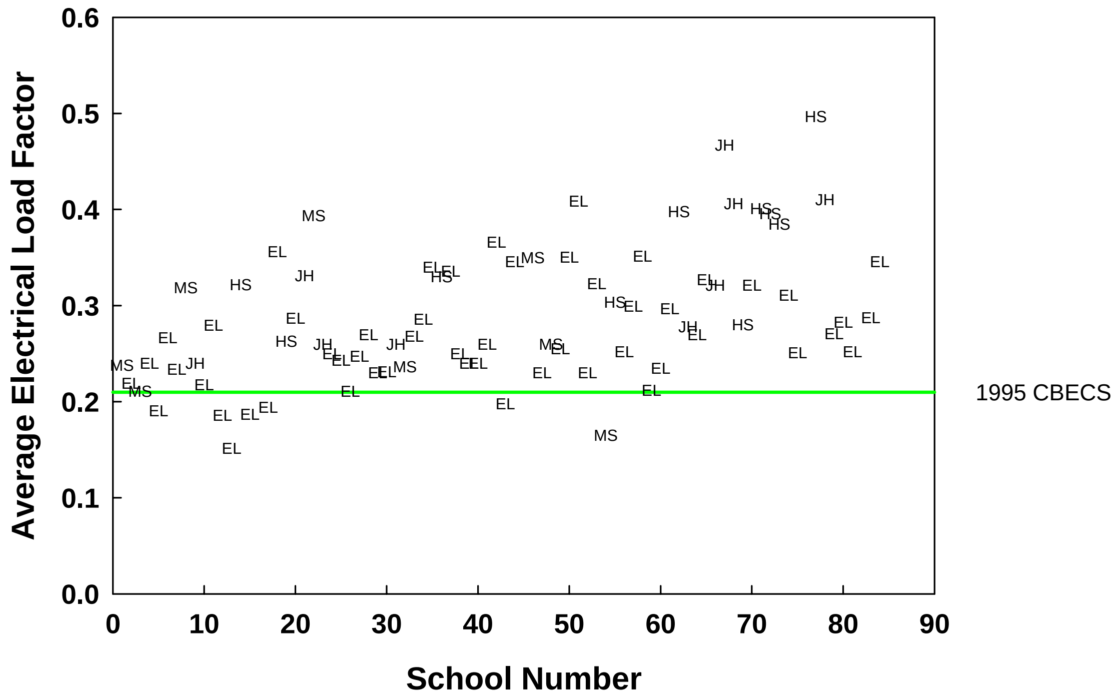


Figure 3.47. Annual average of monthly electrical load factor for all schools. Reference value is the national median value for all educational building types in the 1995 Commercial Building Energy Consumption Survey [1]. Data are ranked from lowest to highest total energy consumption (electricity and natural gas) per unit area (kBtu/ft^2; see Figure 3.7). HS-high school; JH-junior high; MS-middle school; EL-elementary.

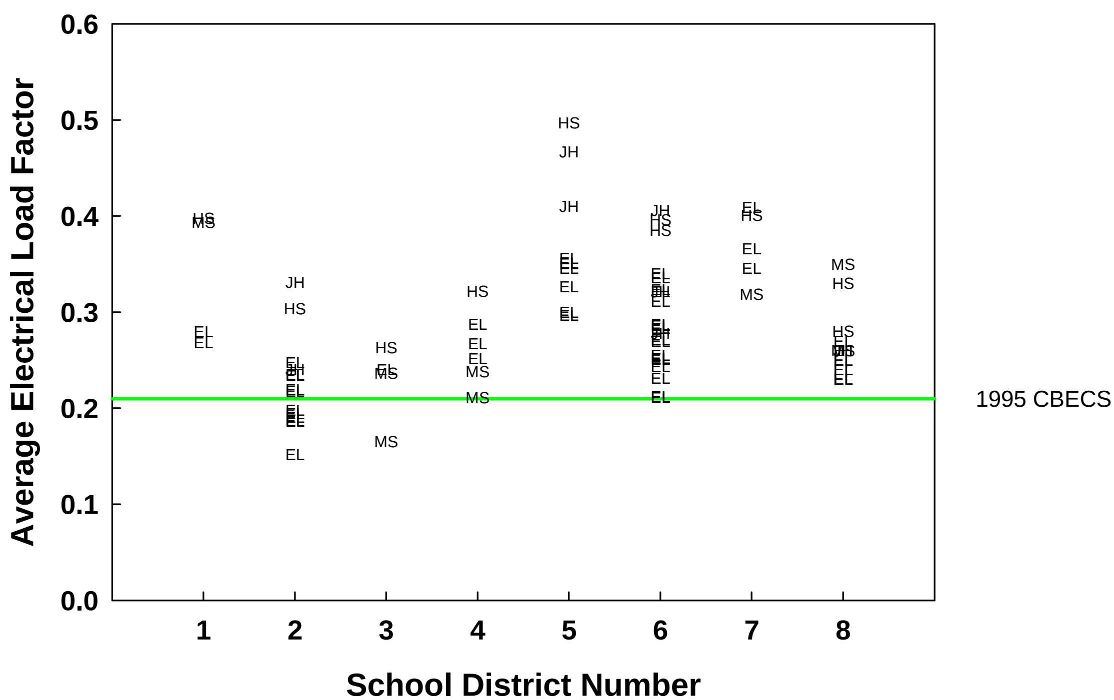


Figure 3.48. Annual average of monthly electrical load factor for schools within each district. Reference value is the national median value for all educational building types in the 1995 Commercial Building Energy Consumption Survey [1]. HS-high school; JH-junior high; MS-middle school; EL-elementary.

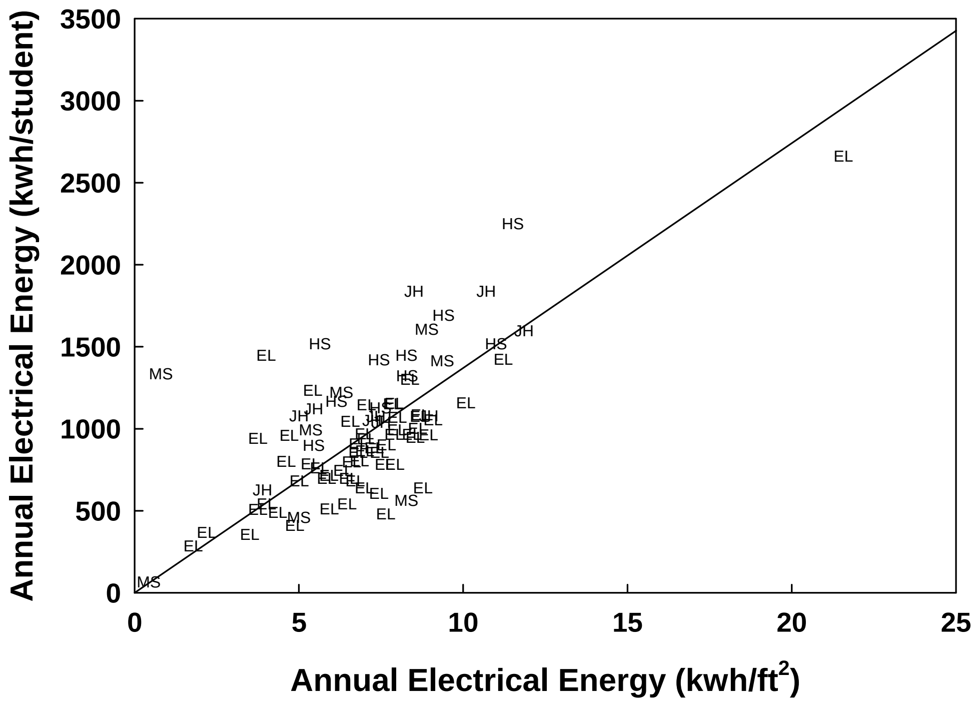


Figure 3.49. Electrical energy consumption per student versus electrical energy consumption per unit area. Solid line reflects a linear regression for all data. HS-high school; JH-junior high; MS-middle school; EL-elementary.

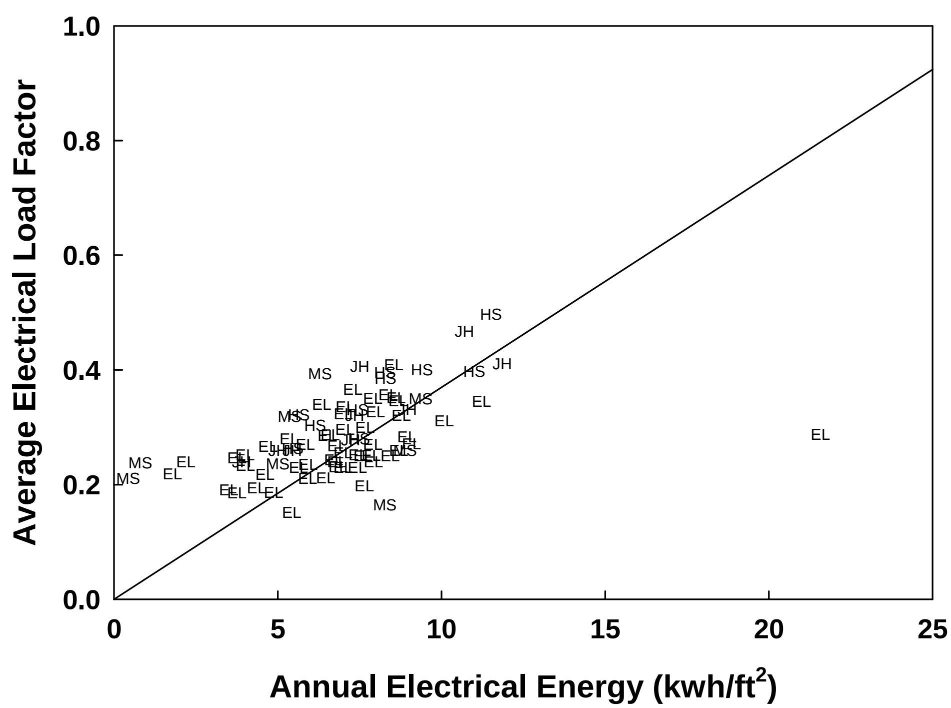


Figure 3.50 Electrical Load factor versus electrical energy consumption per unit area. Solid line reflects a linear regression for all data. HS-high school; JH-junior high; MS-middle school; EL-elementary.

Chapter 4

SCHOOL DISTRICT SURVEY

The final task of the summer was to issue a survey to Arkansas school district superintendents. The e-mailed survey was used in an attempt to better understand the needs of Arkansas school districts relative to building performance, building operation, utilities, and maintenance. The survey contained 17 questions of which 16 required a response of strongly agree, agree, neutral, disagree, and strongly disagree. These questions were grouped in four general categories: building use and control, utility tracking, personnel, and decisions. The one remaining question required a written response regarding each district's primary concern related to utilities. Results of the survey were used to identify areas of greatest need and, to some extent, the relative enthusiasm of each district to participate in any future utility savings/analysis programs.

Surveys were e-mailed to each of the Arkansas school superintendents, over 250, with 77 (>30%) responding by e-mail, fax, or mail. The responses were grouped into three groups for analysis: all responses, smaller district responses (less than 2000 students based on 2003-2004 enrollment), and larger district responses (more than 2000 students based on 2003-2004 enrollment). Forty-eight of the respondents were grouped as from smaller districts and 20 from larger districts. The relative size of the remaining nine were not distinguishable, so their responses were only included in the overall numbers. Figures 4.1 through 4.16 show the survey results for each question and category. The same data are also shown tabulated in the appendix, including the mean and standard deviation. The primary survey findings and conclusions are given below (see Table 4.1 for numeric difference between small and large school district responses).

Overall Findings

1. Nearly all districts use buildings for community activities.
2. Very few of the smaller districts utilize automated building controls; however, most larger districts utilize automated building controls.
3. The majority of districts carefully track utilities; however, larger districts are more likely than smaller ones to track utility usage in an effort to reduce costs.
4. Larger district superintendents receive useful reports that track operating costs; while less than half of the smaller districts receive the same reports.
5. Larger district superintendents feel they would rank well in energy use per student as compared to other districts; while half of the smaller districts responded neutral or unknown.
6. Half to two-thirds of the districts find it difficult to track costs between academic and non-academic facilities.
7. Districts are divided on whether their district has significant potential to reduce utility costs.
8. Most smaller districts feel they would benefit from tracking their utilities, but need more personnel to track utilities; however, most larger districts do not.
9. Nearly three-quarters of the smaller districts need assistance to track utilities; however, nearly three-quarters of the larger districts don't need assistance.
10. Most smaller districts believe their personnel need more training related to optimal building operations, but larger districts are divided on the issue.
11. Most smaller districts could use specialized evaluation assistance to help the district conserve and reduce operating costs.

12. Most districts feel that their utility companies have not helped conserve energy.
13. Nearly all districts indicated that reduced utility costs would free up needed monies for custodial, maintenance, and personnel services.
14. Nearly all districts indicated that tracking utilities would benefit the district.
15. The majority of smaller districts emphasize capital cost minimization over minimizing future utility costs in planning for new buildings; however, larger districts do not.
16. Around half of the districts emphasize capital cost minimization over minimizing future utility costs in planning for existing facility upgrades.

Table 4.1. Combined percentage of strongly agree /agree (sa/a) and disagree / strongly disagree (d/sd) responses for both small and large districts. Questions in red identify stark differences between small and large districts. Refer to Figures 4.1 – 4.16 for questions.

	QUESTION NUMBER															
RESPONSES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
small - sa/a	83	23	64	45	40	69	50	60	73	81	77	27	94	94	57	48
small - d/sd	15	67	15	34	10	21	17	11	8	4	4	44	0	0	28	35
large - sa/a	95	65	95	80	70	53	40	30	20	45	40	26	100	95	32	30
large – d/sd	5	35	0	15	10	42	55	65	70	35	35	68	0	5	63	60

Open Question:

17. What is your district's primary concern related to utilities? Please write your answer below.

Below is a brief summary of concerns for the question 17 responses from district superintendents:

1. Many superintendents expressed great concern over the uncertainty of future utility costs and the continued increase in cost for electricity, natural gas, propane, and diesel.
2. There were concerns related to paying for utility costs with relatively fixed budgets.
3. There is concern and doubt about the cost associated with complying with new indoor air quality standards.
4. Many expressed concern over not properly controlling buildings when not in use and the lack of staff's attention to utility cost minimization.
5. There was concern over the cost and difficulty of operating several decades-old buildings and building systems.
6. Many districts have small maintenance staffs that can only deal with keeping systems running and not optimized.
7. Concerns were expressed about proper design of new building to incorporate energy savings alternatives and utilities impact statement.
8. There were a few concerns regarding utility services, lack of rate increase notification, and natural gas rate structures.

SURVEY QUESTIONS

Category: Building Use and Control
Question #1 – Our school district buildings are used by the community for other than K-12 education.

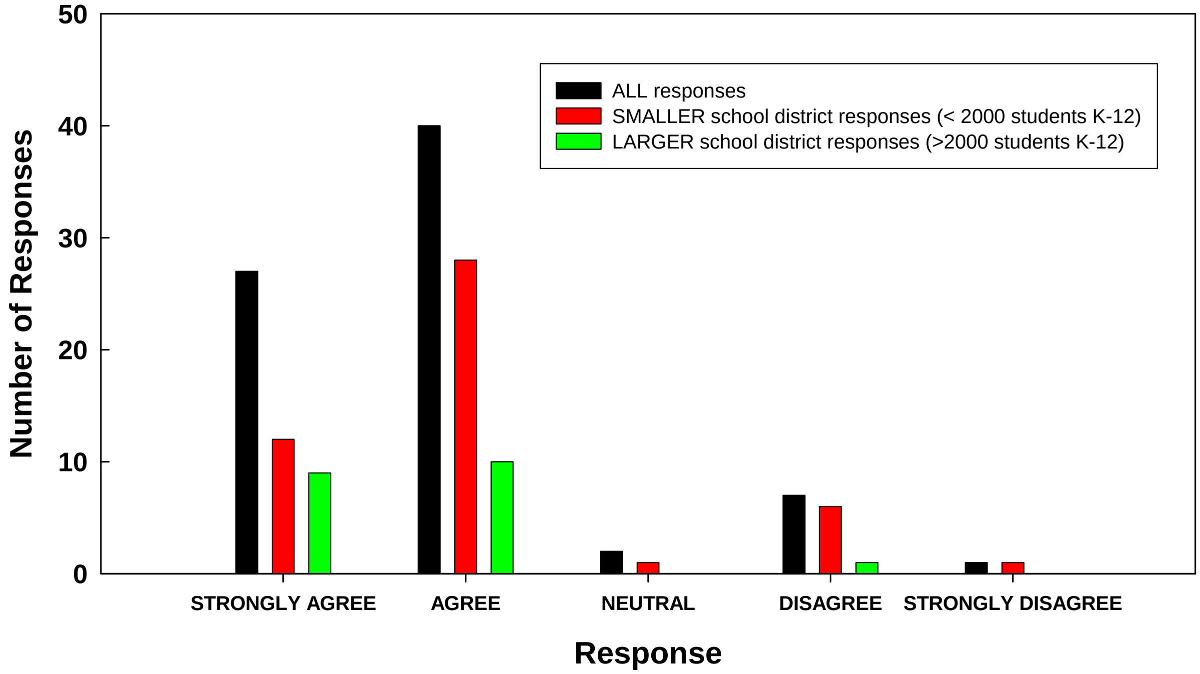


Figure 4.1. Results from Question 1.

Category: Building Use and Control
Question #2 – Our school district utilizes automated building controls in most of our buildings.

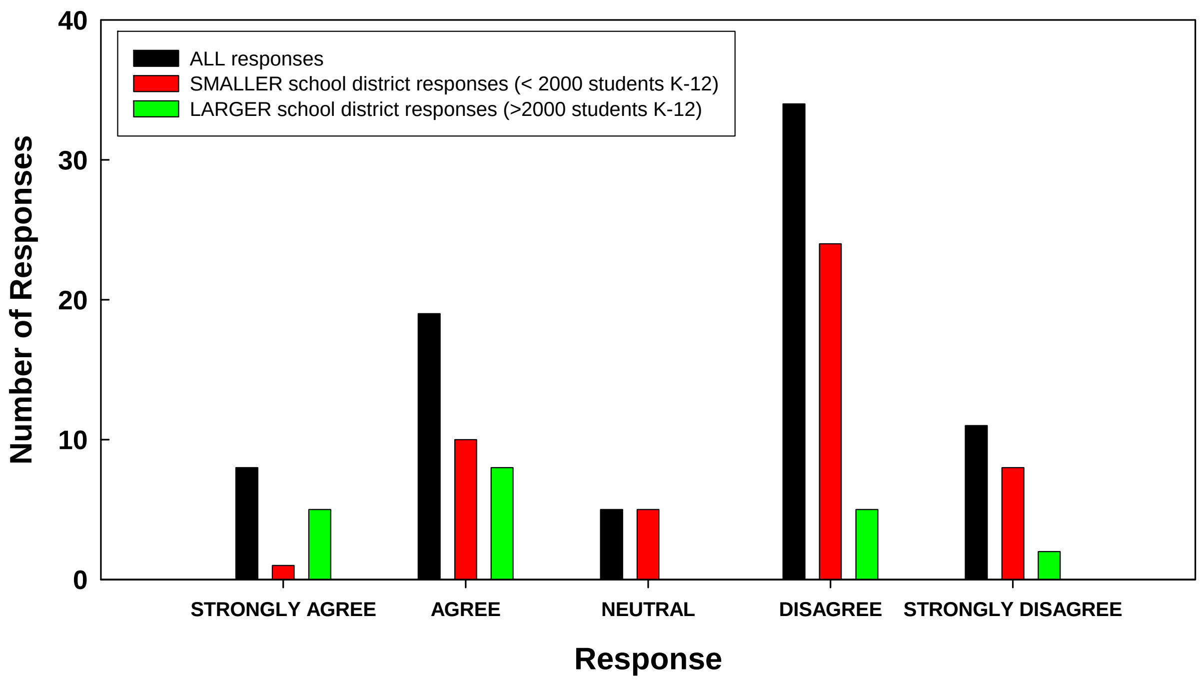


Figure 4.2. Results from Question 2.

Category: Utility Tracking

Question #3 – Our school district carefully tracks water, natural gas, and electricity usage in an effort to reduce operating costs.

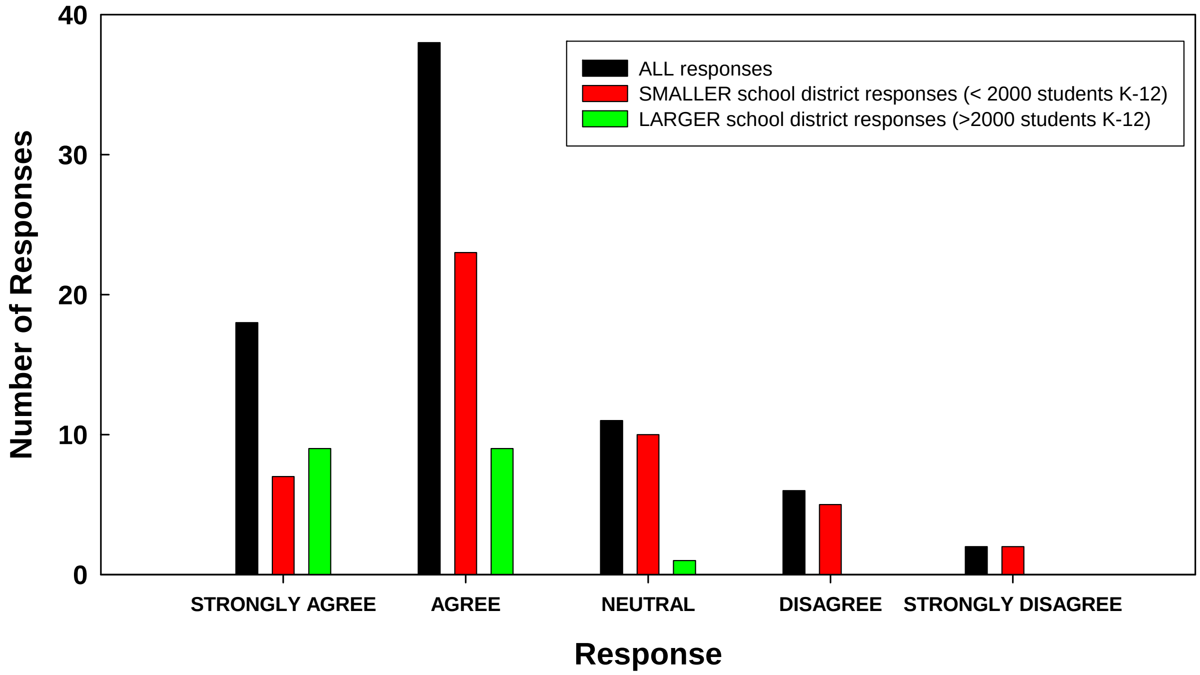


Figure 4.3. Results from Question 3.

Category: Utility Tracking

Question #4 – As the superintendent, I receive useful reports that track the operating costs of each school.

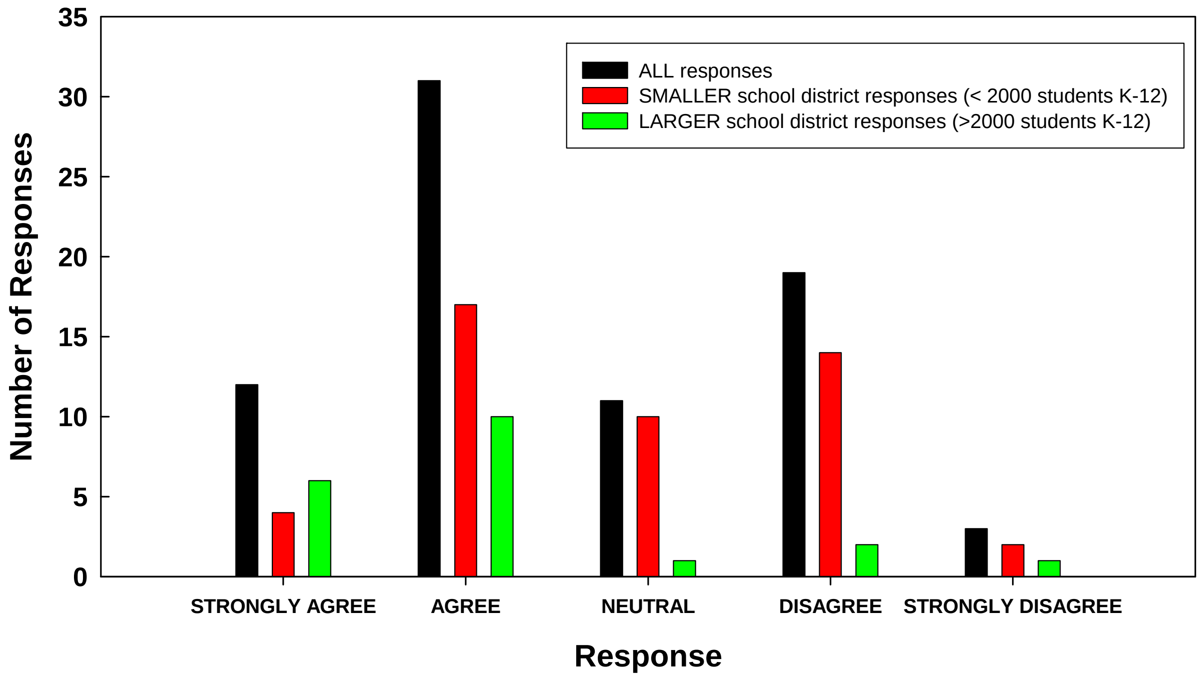


Figure 4.4. Results from Question 4.

Category: Utility Tracking
Question #5 – Our school district would rank well in energy use per student as compared to other Arkansas school districts.

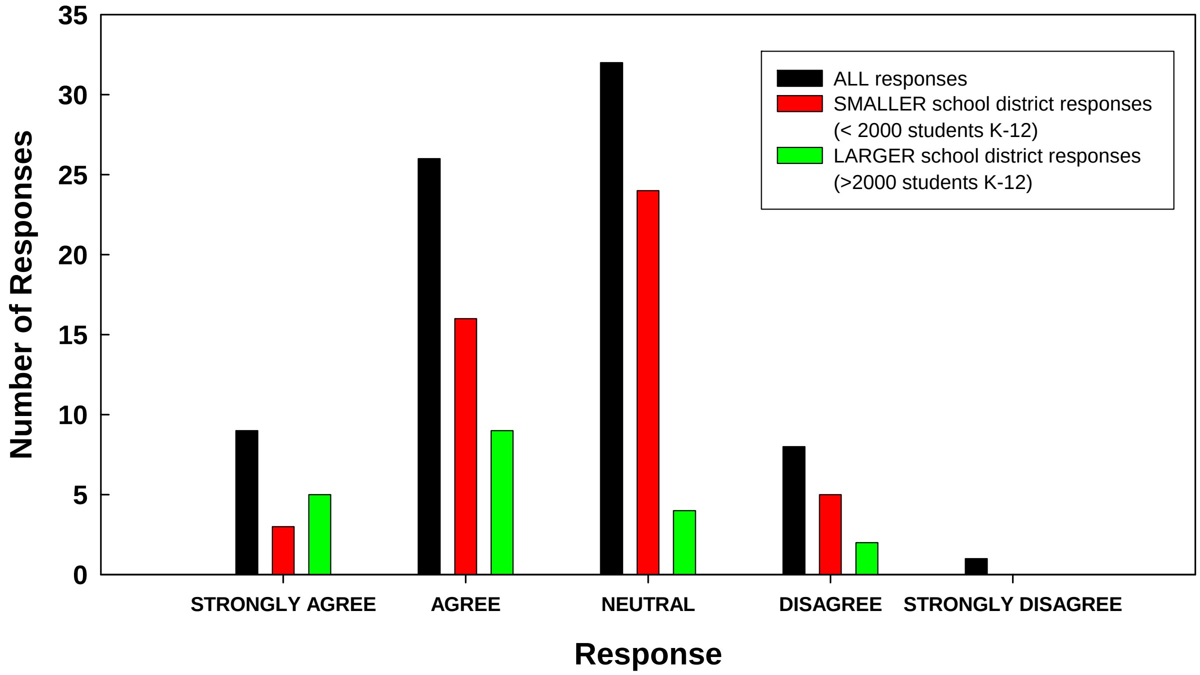


Figure 4.5. Results from Question 5.

Category: Utility Tracking
Question #6 – Our school district finds it difficult to track costs between academic and non-academic facilities.

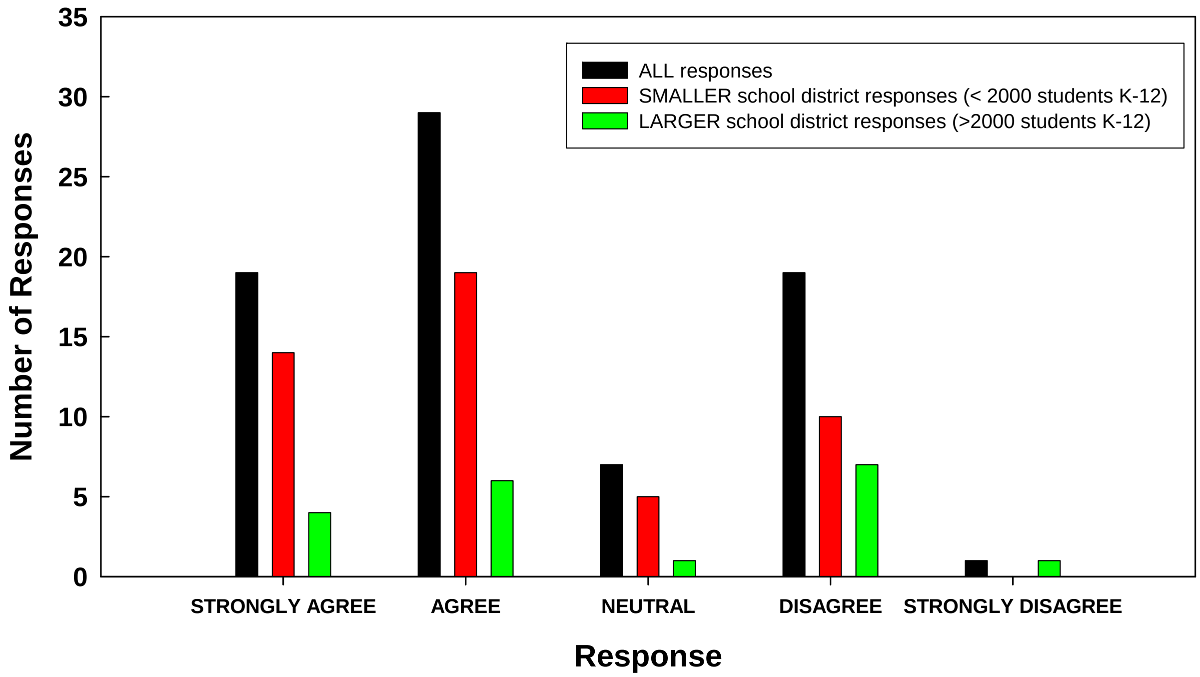


Figure 4.6. Results from Question 6.

Category: Utility Tracking
Question #7 – Our school district has significant potential to reduce utility costs.

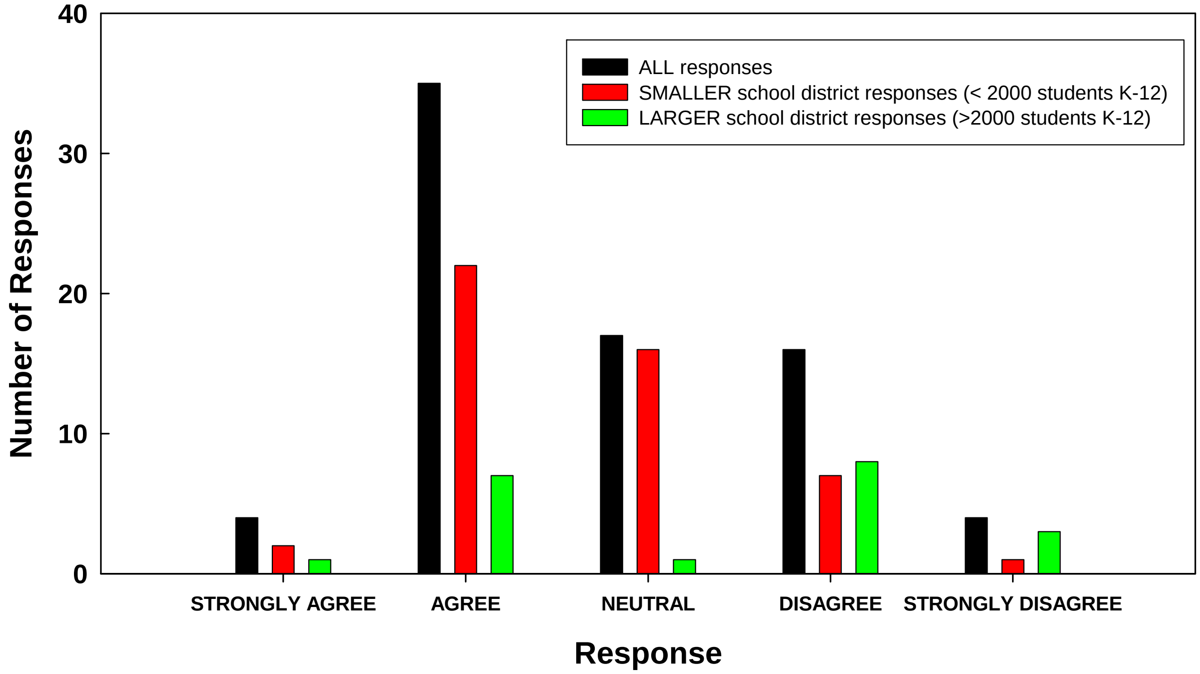


Figure 4.7. Results from Question 7.

Category: Personnel
Question #8 – Our school district would benefit from tracking our utilities, but we do not have the necessary manpower to perform this potentially beneficial task.

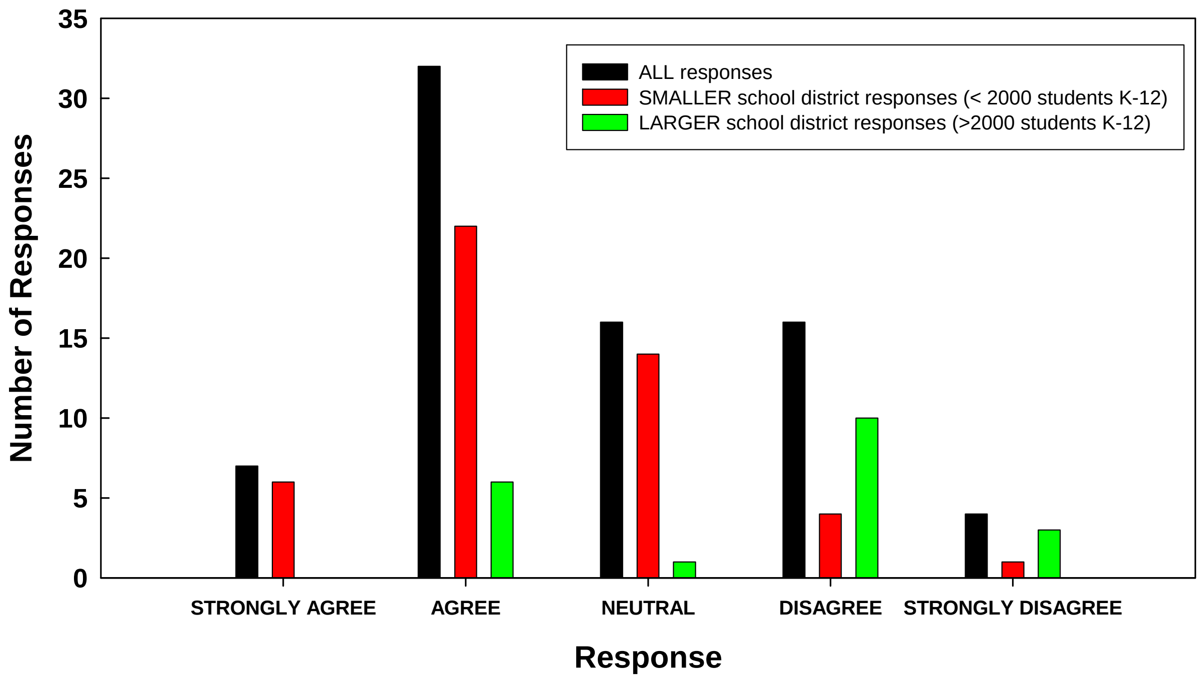


Figure 4.8. Results from Question 8.

Category: Personnel
Question #9 – Our school district could use assistance in tracking our utilities.

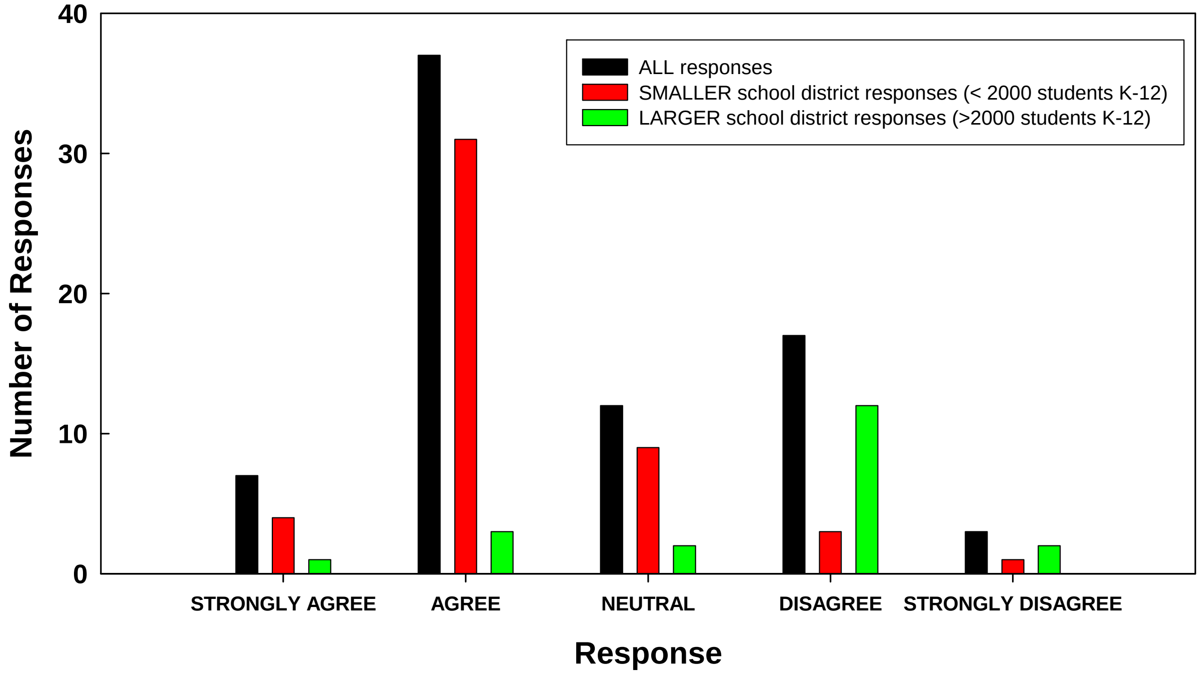


Figure 4.9. Results from Question 9.

Category: Personnel
Question #10 – Our maintenance and facilities operation personnel could use more training related to optimal building operations.

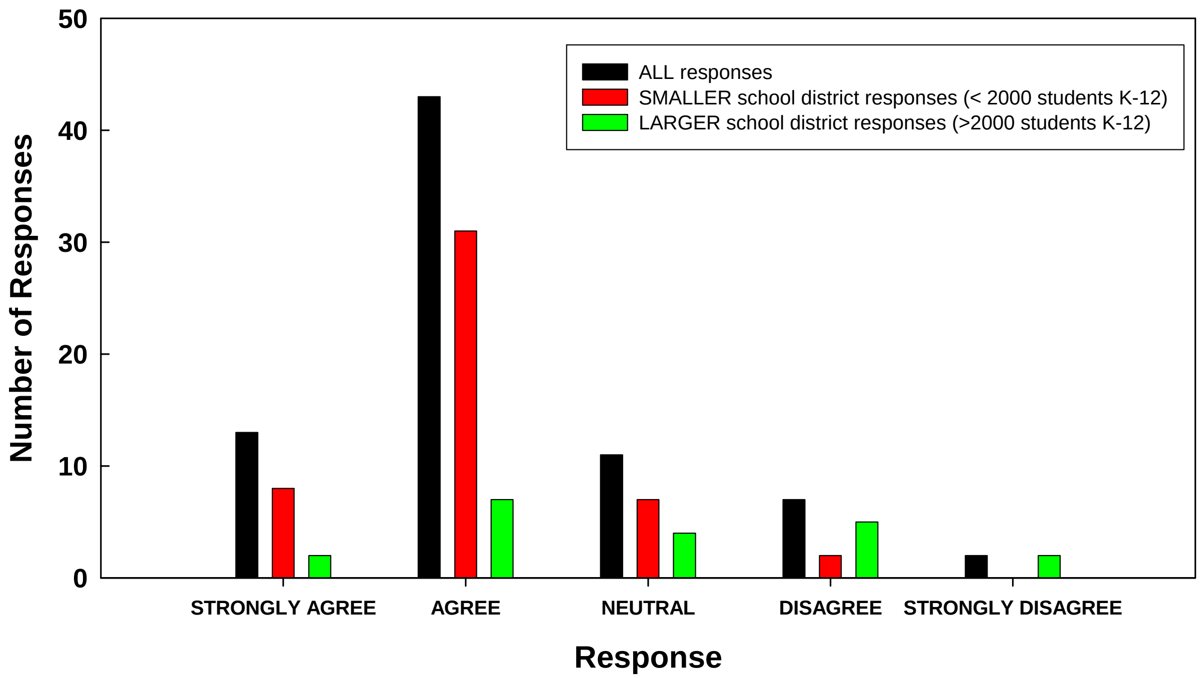


Figure 4.10. Results from Question 10.

Category: Personnel
Question #11 – Our school district could use additional or specialized evaluation assistance to help the district conserve water/energy and reduce operating costs.

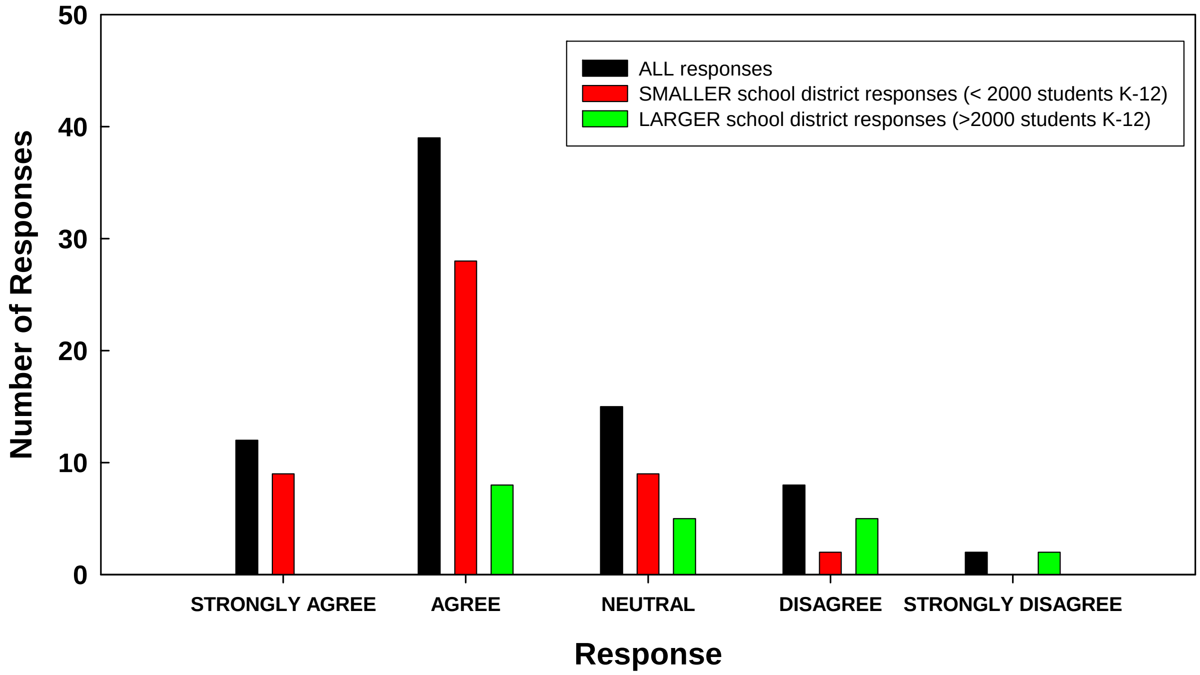


Figure 4.11. Results from Question 11.

Category: Personnel
Question #12 – Our local utility companies have helped our district conserve energy and reduce operating costs.

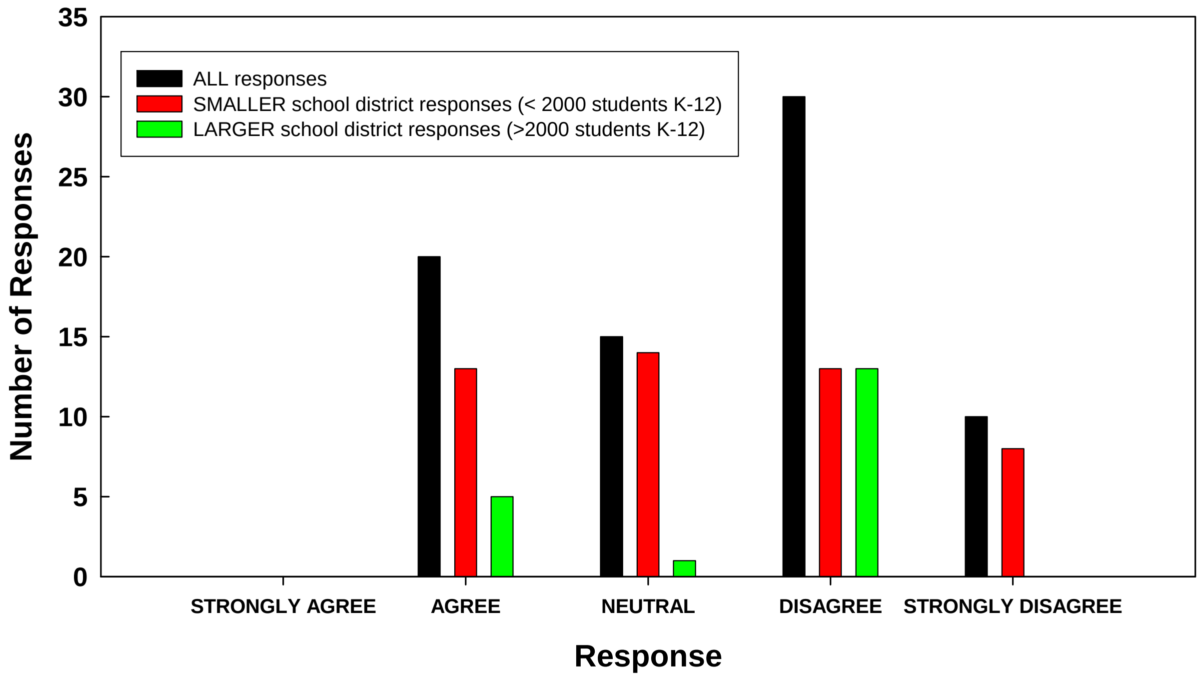


Figure 4.12. Results from Question 12.

Category: Personnel

Question #13 – Reducing utility costs would free up monies very much needed for custodial, maintenance, and personnel services.

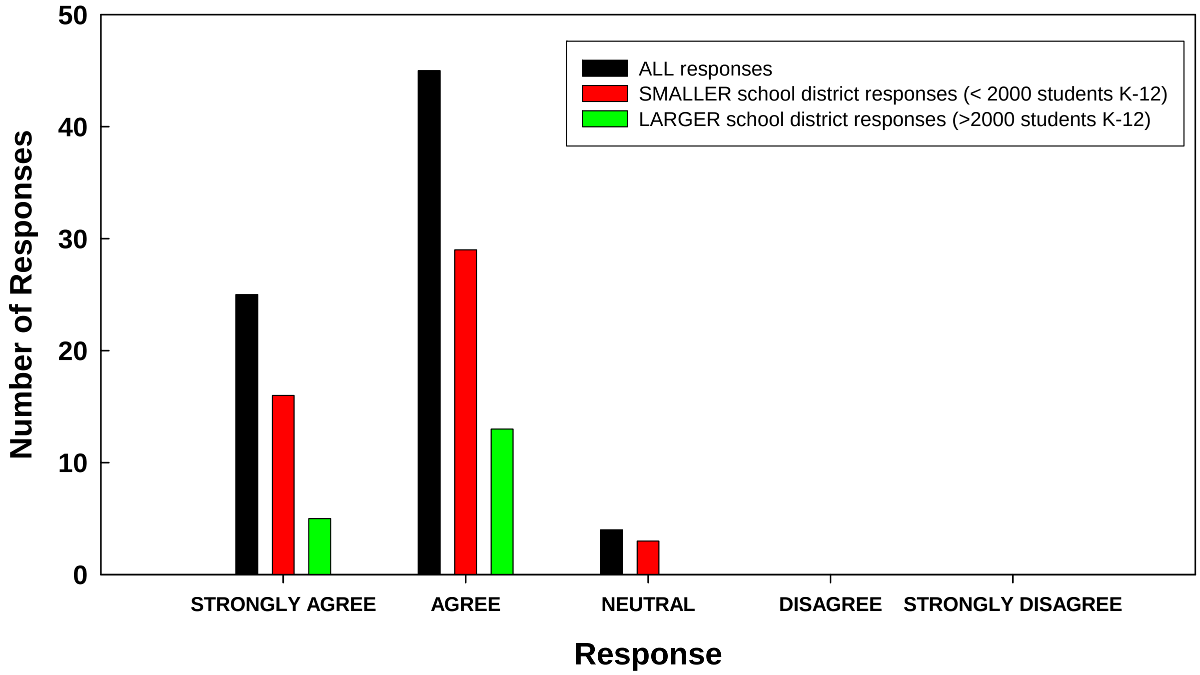


Figure 4.13. Results from Question 13.

Category: Decisions

Question #14 – Tracking utilities (electricity, natural gas, and water) would benefit the district.

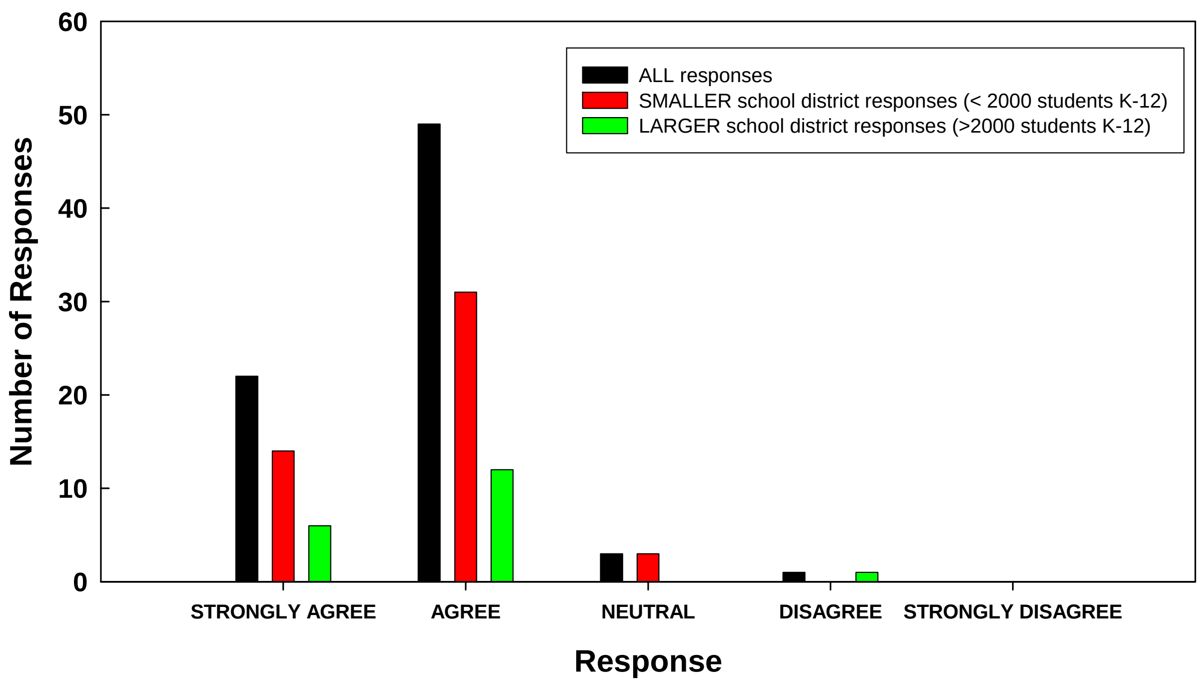


Figure 4.14. Results from Question 14.

Category: Decisions

Question #15 – In planning for new buildings, minimizing capital costs weigh heavier upon decision making than minimizing future utility costs.

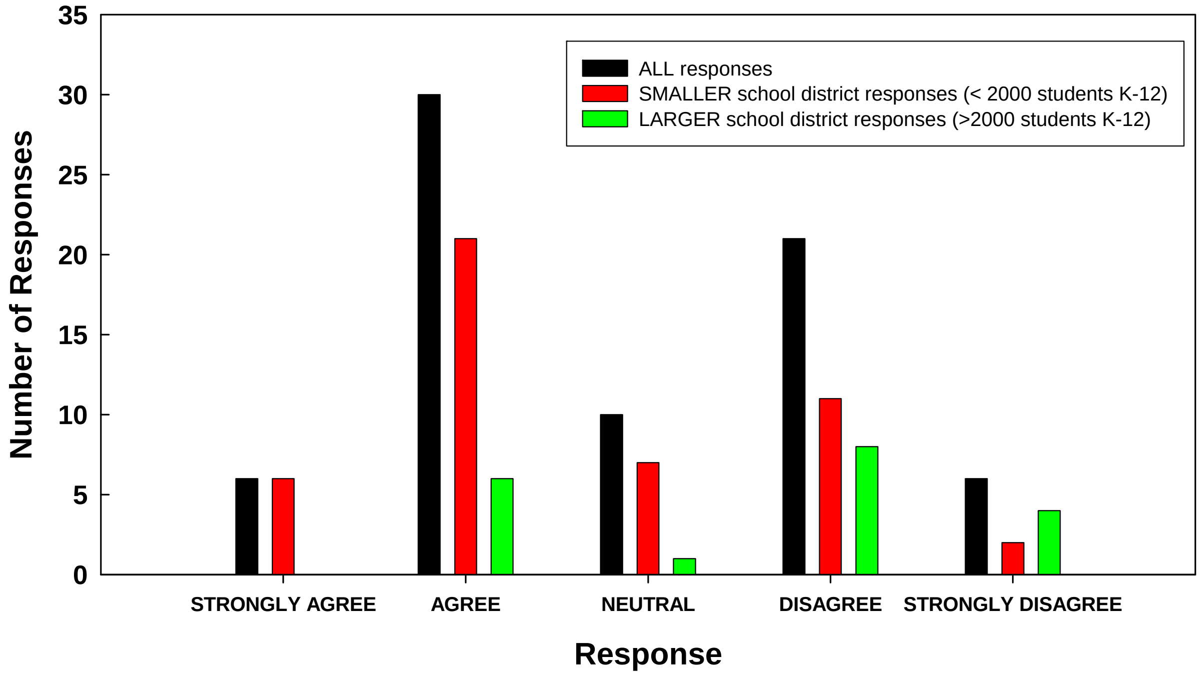


Figure 4.15. Results from Question 15.

Category: Decisions

Question #16 – In planning for existing facility upgrades, minimizing capital costs weigh heavier upon decision making than minimizing future utility costs.

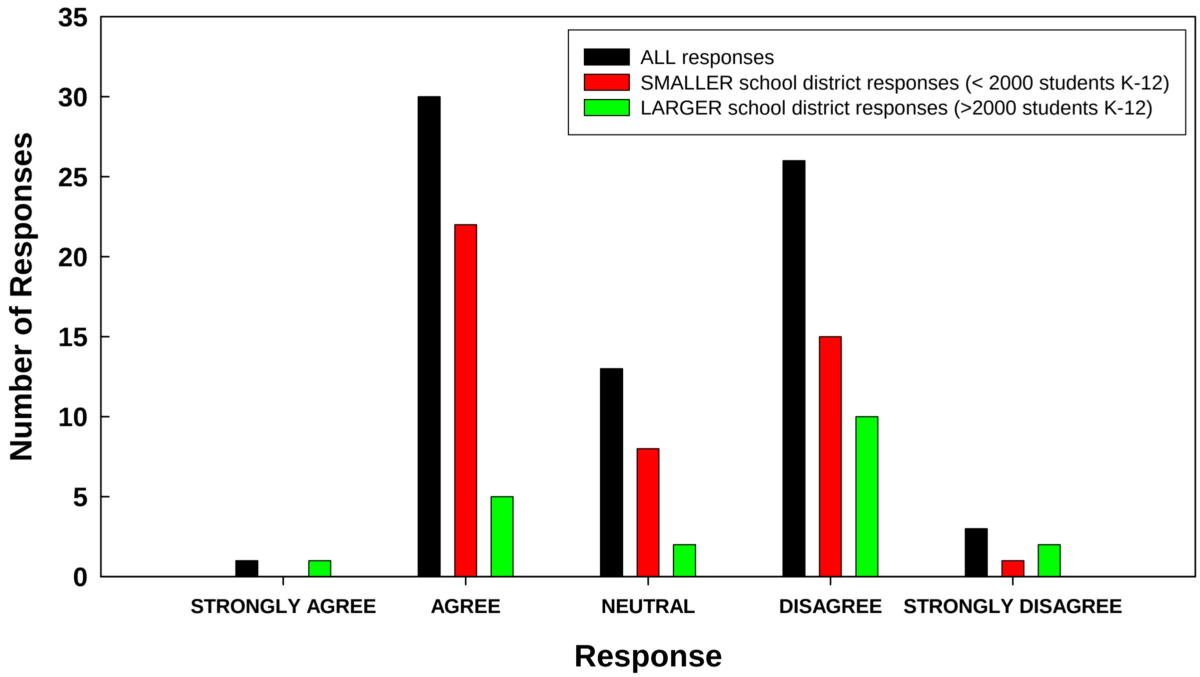


Figure 4.16. Results from Question 16.

Chapter 5

CONCLUSIONS AND FUTURE RECOMMENDATIONS

This project brings to close a pilot utility tracking program that produced several positive outcomes, including a good summer experiences for the summer interns; new and positive interactions between K-12 school districts and University of Arkansas personnel; a benchmarking study with useful values for the eight participating districts and other state school districts; and survey findings that provided insight into the needs of Arkansas schools with regard to building performance, building operation, utilities, and maintenance.

Summary and Conclusions

Below are the primary findings, conclusions and recommendations from this project:

1. The internships were very valuable experiences for the mechanical engineering student interns. Although limited, feedback from the school district contacts was very positive toward the students. In addition, there was value in the interaction between Arkansas K-12 school districts and university students and professor.
2. It was learned that without the student's assistance, 6 of the 8 districts would have found it difficult to complete the pilot study. In several cases, the responsibility for entering utility data was assigned to office assistants that have little or no training, experience, and/or knowledge of utilities. This was primarily due to real and continued time constrains placed on the facilities personnel.
3. Refined utility data for 84 elementary, middle, intermediate, junior-high, and high school campuses were used to compute numerous benchmarking parameters to compare within school districts and statewide. Table 3.1 contains average benchmarking values for each utility and school type. Numerous figures contain actual benchmarking data from the study.
4. By benchmark comparisons, it appears that 10-20% of the schools have the potential for significant utility cost reductions; however, a more detailed evaluation of each situation would be required.
5. Over 30% of the district superintendents responded to the e-mail survey. In general, all school districts: 1) use buildings for community activities, 2) find it difficult to track costs between academic and non-academic facilities, and 3) feel tracking utilities would be beneficial.
6. There appeared a stark difference in the responses of smaller versus larger districts. In general, larger districts: 1) receive utility tracking reports, 2) feel they would rank well as compared to other districts, and 3) do not need personnel or specialized assistance to help them conserve and reduce operating costs. <u>In significant contract to the larger districts, smaller districts generally: 1) do not utilize automated building controls, 2) do not receive as many useful reports that track operating costs, 3) do not know if they would rank well in terms of energy usage per student as compared to other districts, 4) need more personnel and assistance to track utilities, 5) need additional training for their staff to better operate buildings, 6) could use specialized evaluation assistance to conserve and reduce operating costs, and 7) emphasize first cost minimization over future operating costs when planning new buildings and upgrades.</u>

7. Superintendents were asked to also write in their primary concern related to utilities. Most expressed concern over rising and unpredictable prices of natural gas, propane, and electricity and the impact on school budgets. Others expressed concern about operating older buildings, complying with new indoor air standards, small maintenance staffs, designing energy efficient new buildings, and issues with their utility companies.

Overall Future Recommendations

The costs to operate existing school buildings in the state of Arkansas are rising at a rapid rate. This benchmarking study was timely and should be useful to districts able to make comparisons. However, there are several actions that would, if performed, help many state school districts reduce their utility-related operating cost and benefit the state. Based on the findings in this project, these recommendations are to:

1. Make a strong effort through education and assistance to help the smaller school districts that do not have: a) the personnel and/or expertise in utility cost reduction techniques and optimal building operation, b) automated building controls, and c) struggle to minimize life-cycle costs.
2. Use the determined benchmarking parameters as a guide for other school districts across the state.
3. Provide school districts a simpler mechanism for tracking utilities. In many cases, the districts need the information, but do not have the time, personnel, or expertise to track their utilities. Available data in electronic form from local utilities would be helpful.
4. Continue to utilize engineering interns to assist the state with energy/environmental issues. This is not only beneficial to the state by providing inexpensive technical know-how for schools, but also the future engineers who, after the experience, are more likely to seek employment with the state of Arkansas.

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APPENDIX

Table A.1. Overall results and statistics for all 16 school superintendent survey questions.

QUESTION #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ALL DISTRICTS																
Strongly Agree	27	8	18	12	9	19	4	7	7	13	12	0	25	22	6	1
Agree	40	19	38	31	26	29	35	32	37	43	39	20	45	49	30	30
Neutral	2	5	11	11	32	7	17	16	12	11	15	15	4	3	10	13
Disagree	7	34	6	19	8	19	16	16	17	7	8	30	0	1	21	26
Strongly Disagree	1	11	2	3	1	1	4	4	3	2	2	10	0	0	6	3
mean	1.90	3.27	2.15	2.61	2.55	2.39	2.75	2.71	2.63	2.24	2.33	3.40	1.72	1.77	2.88	3.00
s.d.	0.93	1.27	0.97	1.14	0.89	1.16	1.02	1.08	1.06	0.94	0.96	1.03	0.56	0.58	1.17	1.00
SMALL DISTRICTS																
Strongly Agree	12	1	7	4	3	14	2	6	4	8	9	0	16	14	6	0
Agree	28	10	23	17	16	19	22	22	31	31	28	13	29	31	21	22
Neutral	1	5	10	10	24	5	16	14	9	7	9	14	3	3	7	8
Disagree	6	24	5	14	5	10	7	4	3	2	2	13	0	0	11	15
Strongly Disagree	1	8	2	2	0	0	1	1	1	0	0	8	0	0	2	1
mean	2.08	3.58	2.40	2.85	2.65	2.23	2.65	2.40	2.29	2.06	2.08	3.33	1.73	1.77	2.62	2.89
s.d.	0.99	1.07	1.01	1.08	0.76	1.10	0.86	0.90	0.80	0.70	0.74	1.06	0.57	0.56	1.11	0.95
LARGE DISTRICTS																
Strongly Agree	9	5	9	6	5	4	1	0	1	2	0	0	5	6	0	1
Agree	10	8	9	10	9	6	7	6	3	7	8	5	13	12	6	5
Neutral	0	0	1	1	4	1	1	1	2	4	5	1	0	0	1	2
Disagree	1	5	0	2	2	7	8	10	12	5	5	13	0	1	8	10
Strongly Disagree	0	2	0	1	0	1	3	3	2	2	2	0	0	0	4	2
mean	1.65	2.55	1.58	2.10	2.15	2.74	3.25	3.50	3.55	2.90	3.05	3.42	1.72	1.79	3.53	3.35
s.d.	0.75	1.39	0.61	1.12	0.93	1.33	1.25	1.10	1.05	1.21	1.05	0.90	0.46	0.71	1.17	1.14