

Building Performance Analysis: Energy Benchmarking of New York State Schools

Gregory Coleman and Cyrus Afshar, TRC Energy Services

ABSTRACT

There is a great deal of public interest in understanding and reducing energy waste and operating costs at schools since taxpayers ultimately pay the bill. Moreover, energy costs in many schools are second only to salaries, and account for approximately 20% of operation and maintenance. The U.S. Department of Energy estimates that energy efficiency projects in schools could reduce energy consumption by as much as 25 percent and cut school energy costs nationally by more than \$1 billion per year. Energy benchmarking is proving to be a useful tool to help initiate this process.

The New York State Energy Research and Development Authority (NYSERDA) is using both the newest version of the U.S. Environmental Protection Agency (EPA) tool, Portfolio Manager, plus a recently established statewide database to help New York State schools identify and implement energy savings opportunities. This paper presents the results of a benchmarking study that analyzes energy consumption data from over a hundred New York K-12 schools. It reports on a detailed correlation of EPA scores with various other relevant building parameters, such as size, number of students, number of computers, and “source versus site” energy. The study is unique in that the population of buildings is relatively homogenous for the following characteristics: building type and use, geography and weather, fuel types and prices, and regulatory and operating environment.

NYSERDA’s schools program is also unique in that it focuses on the use of benchmarking in the owner decision process. This paper discusses the impact of the EPA score, in conjunction with other benchmarking parameters, in determining what steps schools will take and how they will proceed with improvements.

Introduction and Background

The New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created in 1975 by the New York State Legislature to address the State’s most difficult energy and environmental challenges in ways that drive positive economic results. NYSEDA administers the **New York Energy SmartSM** program, which supports public-benefit programs during the transition to a more competitive electricity market. Programs are funded by a System Benefits Charge (SBC) on the electricity transmitted and distributed by the State’s investor-owned utilities. To ensure NYSEDA provides the best service to its customers, it continuously reviews programs and initiatives to identify new opportunities and potential areas to improve. As part of this ongoing improvement process, NYSEDA determined that the K-12 schools sector could benefit from additional services. NYSEDA issued a competitive solicitation to obtain a number of services for the schools market. The result of this competitive selection process was a contract with TRC to support NYSEDA’s **Energy Smart Schools Program**.

A cornerstone of NYSERDA's **Energy Smart Schools Program** is energy benchmarking. This paper presents the development of NYSERDA's Energy Smart Schools approach to energy benchmarking for its customers as well as the results to date from over 125 K-12 schools throughout the State. The program is ongoing.

NYSERDA's approach to energy benchmarking is designed to provide two major, interrelated results. First, it gives both NYSERDA and its schools customers a multi-parameter baseline of energy use and cost to forecast and measure future improvement against. As management theorist Peter Drucker put it, "If you can't measure it, you can't manage it."

Second, benchmarking combined with recommendations of how to find the most likely energy savings provides customers with a path to action, with a tool to overcome inertia, and with the information needed to take the next step. Every organization uses different parameters or indicators in its internal decision making process. In the case of buildings energy-related systems, those decisions reflect whether and how to spend resources. In response to the market's question of prioritizing resources, NYSERDA's energy benchmarking question was, "what are the common key parameters that influence decisions, which can be cost-effectively tracked and placed into the hands of the decision makers?"

National Benchmarking: U.S. EPA Portfolio Manager

NYSERDA started integrating benchmarking into its school's efforts in 1998, with a focus on use of the EPA's Benchmarking Tool—Portfolio Manager. The EPA made a commitment to energy benchmarking several years ago, which ultimately led to the availability of today's web-enabled tool—Portfolio Manager. Versions of Portfolio Manager are available for several building types, including K-12 schools. The most recent update of the version for schools was released in late January, 2004. The purpose of this paper is not to present a detailed description of Portfolio Manager, however, a brief description of the model is presented below in order to place this work in New York State in context for the reader.

The output of Portfolio Manager is a single energy benchmark—a 'score' on a 1 to 100 scale. That score represents the percentile ranking of the normalized energy intensity of a particular building when compared to a national database of schools. For example, a score of 30 means that 29% of schools nationwide are more energy intensive per square foot and that 69% are less energy intensive per square foot. Portfolio Manager requires the following inputs to develop the score (EPA 2003):

- Gross square footage
- 12 months of concurrent energy consumption for all fuel types
- Weekly hours of occupancy
- Number of students
- Number of months in operation
- Percent of building that is cooled
- Whether there are cooking facilities in the building
- Number of computers in the building

Portfolio Manager uses these values as inputs to a sophisticated model that normalizes for each of these variables. It also includes both a climate (heating and cooling degree day) and a weather normalization routine. The model generates the percentile score through comparison of a building's energy use to the data in the 1999 Commercial Buildings Energy Consumption

Survey, compiled by the Energy Information Administration of the U.S. Department of Energy. This survey data is the model's baseline.

New York State Benchmarking: NYSERDA's Energy Smart Schools Program

As part of the contract to support the K-12 schools effort in New York, NYSERDA tasked TRC to benchmark the energy performance of K-12 schools in the State, starting with the EPA Portfolio Manager tool. As noted above, the goal of this effort was to inspire energy managers and business officials to take cost-effective action.

TRC quickly recognized that the scope of this task afforded a unique opportunity not available to those trying to accomplish nationwide benchmarking. That is, we had a significantly more homogenous universe of buildings with which to work.

New York State schools have been designed and constructed over the years using similar design criteria and under the same State building codes, although those codes have certainly evolved over time. The school buildings are then operated under the same regulatory conditions, that of the New York State Department of Education. Finally, New York State covers a large geographic area, however, weather patterns affecting energy consumption in Albany, Buffalo, and Syracuse are not, for example, as different as between Albany, NY and Austin, TX; or Syracuse, NY and Sacramento, CA. The cumulative effect of these factors meant that TRC did not have to account for as many differences among the schools, while still providing each school with valid indicators to make implementation decisions.

This opportunity was used to develop a list of six useful indicators to use as benchmarks without being constrained by the need for a perfect regression algorithm (Sharp 1998). We developed the list based on discussions with NYSERDA staff, school business officials, school superintendents of buildings and grounds, and energy managers with various Boards of Cooperative Educational Services (BOCES) around the state. The indicators being analyzed and reported to schools include the following, and are discussed in detail in the rest of this paper:

- EPA Score
- Site energy—kBtu/sq. ft.
- Electric use—kWh/sq. ft.
- Heating fuel use—kBtu/sq. ft.
- Energy cost—Dollars/sq. ft. and Dollars/student

The Benchmarking Process

In order to accomplish this task, a start-to-finish process of data collection was devised including: validation, analysis, reporting, and follow up. This process was designed to ensure a consistent output of high quality data and analysis that customers could rely on in reaching, supporting, and implementing a decision to proceed with improvements.

Data Collection

This task began by focusing on designing a data collection process, including creating a Data Request Form, which is the primary vehicle for gathering building-specific information for each school. The Data Request Form is shown in Figure 1 below.

Figure 1. Energy Benchmarking Data Request Form



Energy Benchmarking Data Request

Please submit one form for each building.

Please attach copies of the most recent 12 months of utility bills.

General Info

Name of Building _____

Address _____

City _____ Zip Code _____

Point of contact: Name/Title _____

Address _____

Phone _____ E-mail _____

Fax _____ Mobile _____

Building Info

Year Built _____ No. of students _____

Size of building (sq. ft.) _____ No. of floors _____
(Do **not** include unheated attics or basements)

Type of school: High School _____ Middle/Junior High _____ Elementary _____ Other _____

Electric Utility _____ Electric Utility Account # _____

Gas Utility _____ Gas Utility Account # _____

How is building heated? _____ No. of personal computers _____

How is building cooled? _____ Percent of building cooled _____

Does the building have cooking facilities? Yes ___ No ___

No. hours of occupancy per week _____ No. months operated per year _____
(Times when the majority of the building is being used)

One of the major considerations for this process was that personnel at both the district and individual school level are quite focused on the tasks required to keep buildings functioning. Any request for additional effort can often be perceived as interference—something that needed to be avoided for the benchmarking process to work. Therefore, the form was made as straightforward and easy to use as possible. Most of the form's parameters are necessary inputs in Portfolio Manager and those that are not have proven to be useful in additional analysis of energy use performed for the schools as part of this task.

When a Data Request Form is sent to an energy manager, 12 consecutive, concurrent months of electrical and natural gas/fuel oil cost and use information is also requested. It is stressed to facility managers that all they need do is “pull the utility bills from the file cabinet and mail them to us.” No additional effort on their part is requested and the facility managers are assured that their bills will be returned.

Data Validation

When the Data Request Form and utility data are submitted by a school, a considerable amount of time is spent verifying and validating the data, as well as following up with school staff to ensure all information needed to proceed with benchmarking has been submitted.

Several obstacles arose as data was gathered. Virtually 100% of the energy data collected required some form of validation and follow-up with respective energy managers. Specifically, about 20% of the data was fairly complete and ready for analysis, requiring only double-checking and minor correction. Another 60% required considerable contact with building operators, significant correction, and final, triple-checking of data. The last 20% was extremely labor intensive, requiring regular contact with building operators, and repeated review of the data.

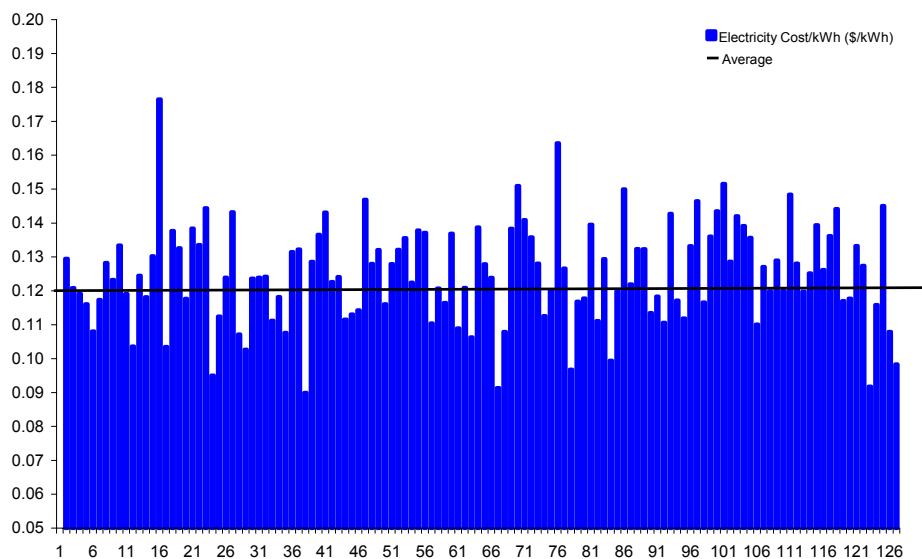
Some of the data validation issues encountered in the benchmarking analysis were:

- The electric and heating fuel use and cost information were often incomplete. For instance, utility cost information sometimes included only supply costs and left out electric transmission or distribution or natural gas transportation costs.
- Electric and gas lines were sometimes shared by more than one building. In order to document a benchmarking score, several buildings sometimes needed to be combined as one, making it very difficult to generate accurate energy analysis at the building level.
- The energy use or cost information given by the building staff was often partially inaccurate and the staff was unable to determine which part was accurate and which part was inaccurate.
- It was often difficult for managers to accurately estimate the weekly hours of occupancy of their school. With evening and weekend activities, it was difficult to estimate how much of the building was populated during different times of the week.
- Managers sometimes inadvertently included unconditioned space as part of the overall building square footage.
- The student population for community education centers was hard to determine accurately, automatically making all the data normalized by number of students less accurate for these buildings.
- Some of the buildings in use were designed for students with special needs, so the energy use in these schools was considerably different from other schools. This made those

buildings appear to be poor energy performers even though their function was different from other schools.

The final element in the quality check of our data involved two steps. First, a given parameter for each of the schools was plotted with the school name on the x-axis and the parameter on the y-axis. Schools whose values fluctuated a great deal from the average in either the positive or negative direction were noted for further follow up. The facility manager was then contacted to determine if there were any reasons why that particular value would be so different from similar schools. If there were valid reasons, the data was kept. If there were no obvious reasons why the value would be significantly different, more data was requested and analyzed with the school's facility manager until the difference could be explained. An example plot using unit cost of electricity is shown in Figure 2 below.

Figure 2. Unit Cost of Electricity (\$/kWh) by School



In the case shown on the graph, there are three outliers showing potential inaccuracies. Therefore, follow up was conducted with the apparent '\$0.18/kWh school' and the two apparent '\$0.09/kWh schools' to ensure that the values were correct. For this data element, the data is correct.

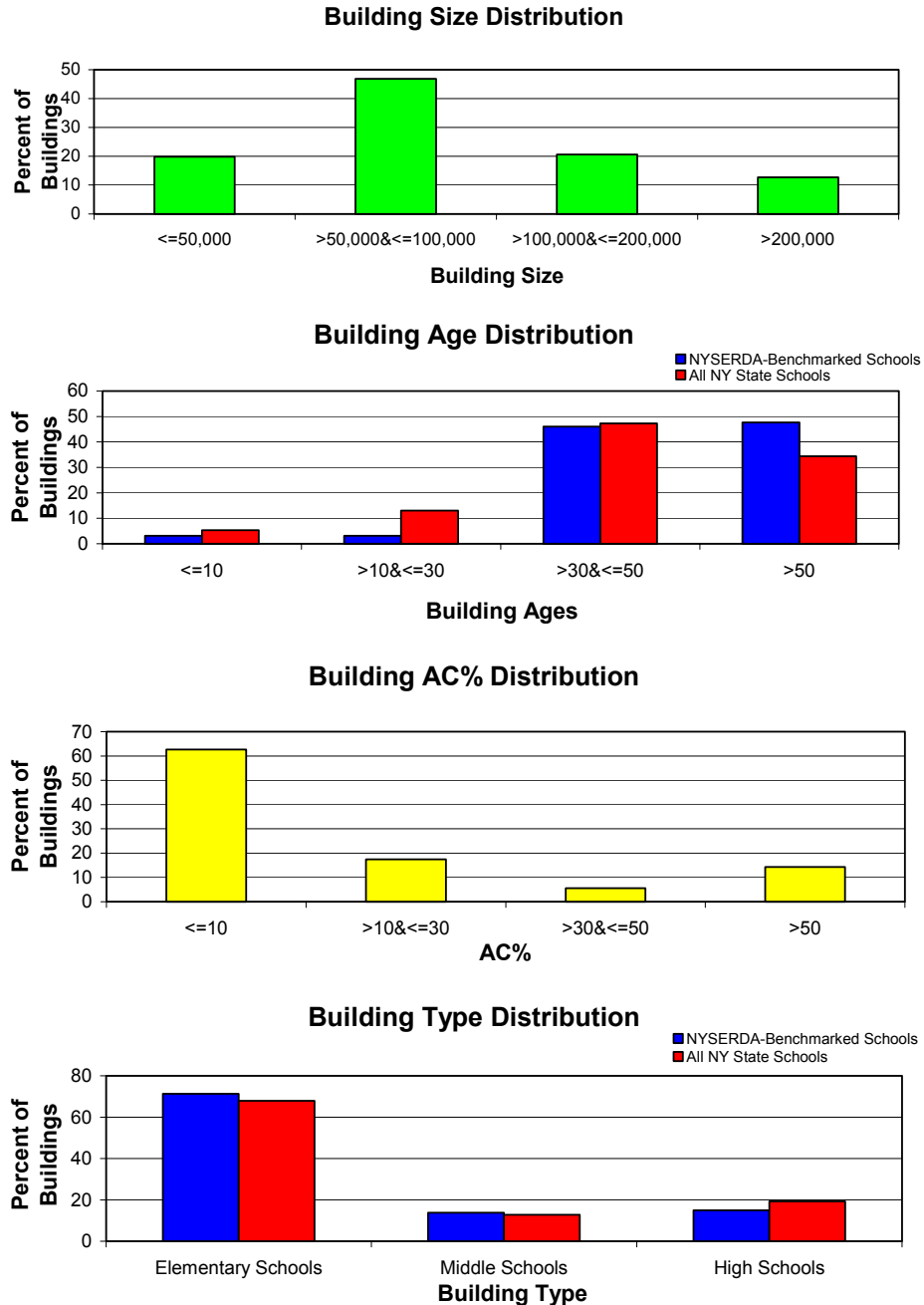
Data Analysis

Once a comprehensive file of information was received and validated for a school, all of the inputs were entered into the EPA's Portfolio Manager to generate a benchmarking score. The EPA Score was used as a starting point to populate a New York Benchmarking Database, which is an Excel file that serves as the backbone of the benchmarking analysis performed. There are presently 126 New York State schools representing nearly 14 million square feet of space in the database.

Breakdowns of the population of buildings in the database by size, age, amount of air conditioned space, and building use (elementary, middle, or high school) are shown in Figure 3

below. Where possible, the NYSERDA benchmarking database population is compared to the entire New York State K-12 building population.

Figure 3. Breakdown of Schools in the NYSERDA Database



Source: NYSERDA & New York State Department of Education 2003

The NYSERDA benchmarking database also contains all of the information we received from the Data Request Form as well as the utility use and cost information. A snapshot of some of the basic values in the database is shown in Table 1 below.

Table 1. Schools Benchmarking Database Values

Parameter	Average	Median
Building Size (sq. ft.)	108,766	78,775
U.S. EPA Score	31	25
Total Energy (kBtu/sq. ft.)	88.8	86.6
Electric Use (kWh/sq. ft.)	6.2	5.6
Heating Fuel Use (kBtu/sq. ft.)	65.9	64.7
Energy Cost (\$/sq. ft.)	\$1.25	\$1.23
Energy Cost (\$/student)	\$213	\$201
Student Density (students/100,000 sq. ft.)	617	653
Electric Cost (\$/kWh)	\$0.134	\$0.124
Fuel Oil Cost (\$/gal)	\$1.01	\$1.02
Natural Gas Cost (\$/therm)	\$0.71	\$0.69
Weekly Operating Hours	66	70
Operating Months per Year	11	11

By generating so many evaluation points from the information provided by the schools, the analysis provided to each school becomes far more comprehensive and valuable to the school's decision makers than it otherwise would have been. After validating all data, analysis began to search for trends in the data. Correlations between the EPA score and many of the input parameters used to generate the score were sought. These possible correlations were then tested one at a time between EPA score and weather, percent of the facility air conditioned, age of the building, size of the building, type of building (elementary school, middle school, or high school), fuel type (natural gas or fuel oil), the building's hours of use per week, its months of use per year, and its electric vs. heating loads.

With the exception of fuel type (natural gas vs. fuel oil), there seemed to be little correlation between the EPA score and the individual input parameters. Linear regression analysis generated a very low R-squared value, well below 0.50, in each case. The one exception to this was for fuel type, and the scores are show in Table 2 below.

Table 2. Correlation Among Benchmarks for Natural Gas vs. Fuel Oil Heated Schools

Parameter	Natural Gas-Fired Heating	Fuel Oil-Fired Heating
No. of Buildings	104	22
Average Site Energy	86.7 kBtu/sq. ft.	98.4 kBtu/sq. ft.
Median Site Energy	85.2 kBtu/sq. ft.	95.9 kBtu/sq. ft.
Average EPA Score	33	22
Median EPA Score	28	17

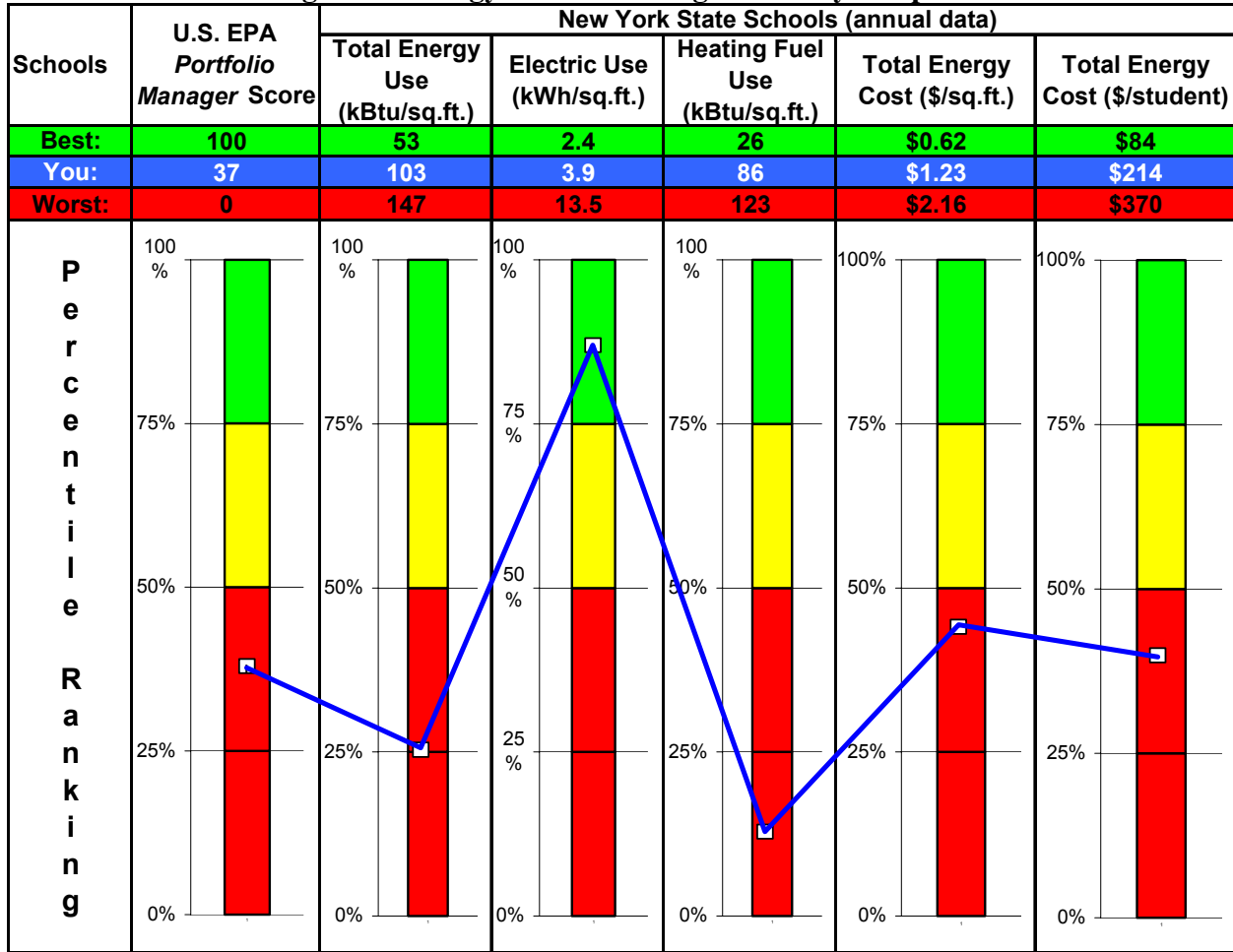
Reporting

The next need was for a way to convey all of this information and analysis to the schools in a manner best designed to motivate action. As noted above, a great deal of time was spent deciding which parameters would be the most useful to them. Ultimately, parameters were chosen to tell a story about each school that would lead to action. It was decided that electrical and heating systems were the most critical energy systems to focus on and that total energy cost would be useful to know in order to convince school boards and business officials that funding

for energy savings opportunities belong in their school district’s annual budget. Therefore, the Portfolio Manager score, the total energy use (kBtu/sq. ft.), the electric use (kWh/sq. ft.), the heating fuel use (kBtu/sq. ft.), and the total energy cost (\$/sq. ft.) and (\$/student) are shared with each school participating in NYSERDA’s **Energy Smart Schools Program**.

Figure 4 below is a sample of the executive summary graphic from one school’s benchmarking report.

Figure 4. Energy Benchmarking Summary Graphic



This graphic is presented on the first page of every benchmarking report and summarizes each of the above indicators for the customer. The following pages of the report provide a short discussion of each of the indicators, what they mean, and where the school stands relative to other New York State schools.

One of the goals of the **Energy Smart Schools Program** is to provide K-12 schools with an improved ‘entry’ into the appropriate NYSERDA support programs. Some of the NYSERDA programs relevant to schools include a subsidized energy audit program for small building owners, a 50/50 cost-shared technical assistance program for more comprehensive studies, a high-efficiency equipment incentive program for minor upgrades, a major support program for new construction, and a building operator certification training program to improve operations and maintenance. Therefore, at the end of the report, each school is provided recommendations for next steps and presented with information about the relevant NYSERDA programs above that

could help support those next steps. Depending on the urgency conveyed by the school or by the indicators in the report, school officials are contacted following delivery of the report to determine what additional support may be needed to begin implementation efforts.

Results and Conclusions

Without even visiting the school facility, recommendations can be provided to building operators that lead to cost effective action. For instance, the summary graphic shown on the previous page tells a story about this particular school. Both the EPA Score and the annual Site Energy use are “in the red.” These factors clearly indicate a building in need of attention. The electricity use indicator, however, shows that the building is doing better than 85% of other New York State schools. So lighting, pumps, motors, and plug load are probably not the source of the ‘problem’ with this building’s energy use. Continuing analysis of the building shows heating fuel use at the 10th percentile, which leads to a conclusion that the heating system may be the more cost effective place to start looking for improvement opportunities.

This school was encouraged to proceed with an energy audit focusing on the heating system and the building envelope. As part of this referral, the school was informed of one of NYSERDA’s programs where the audit would only cost them \$600. This amount is ultimately returned to the school if it can demonstrate it implemented more than \$600 worth of audit-recommended upgrades. Suffice to say, this school took action!

With the energy unit cost values slightly worse than average, it was also recommended that the district’s superintendent of buildings and grounds work with the school’s business official on their utility supply contracts. There can be substantial benefit to joining a consortium to participate in competitive utility supply bidding or to work with their utility account representative to explore another utility tariff that might be a better fit.

NYSERDA’s **Energy Smart Schools Program** and its benchmarking component are ongoing. More schools are constantly participating and many schools continue to send newer, updated data. With simple, inexpensive desktop analysis, NYSERDA’s **Energy Smart Schools Program** is generating indicators that not only show school officials which buildings to focus on, but even which systems in those buildings to start with. While benchmarking is not a substitute for onsite energy audits, it can be a great first step for energy managers and can help focus the goals of an energy audit. With a minimal investment of time and no investment of capital, building owners can focus resources where they are needed most. This facilitates cost effective action, makes our nation’s schools more energy efficient, and saves taxpayers money. In short, benchmarking is a great idea!

References

- Environmental Protection Agency (EPA). 2003. *Technical Description for the K-12 Model*. Washington, D.C.
- Hinge, Adam, James Rutherford, David Abrey, John DaSilva, Elizabeth Titus, and Edward Smyth. 2002. “Back to School on Energy Benchmarking.” In *Proceedings of the 2002 ACEEE Summer Study*. Monterey, Calif.
- Sharp, Terry. 1998. “Benchmarking Energy Use in Schools.” In *Proceedings of the 1998 ACEEE Summer Study*. Monterey, Calif.