

Benchmarking K-12 Schools: How the Building Energy Performance System Continues to Track and Compare Energy Data in the Northeast and Mid-Atlantic

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ABSTRACT

Starting in 2003 and continuing today, an immense amount of building and utility data has been compiled from over 1,650 K-12 Schools in over 370 districts throughout the Northeast by four separate organizations: NYSERDA, NJ Board of Public Utilities, PPL Electric Utilities, & the NH Public Utility Commission. This data has been benchmarked and reported back to the schools providing informative energy use comparisons, consumption trending analyses, and recommendations for cost-effective energy efficient building improvements. Starting by using U.S. EPA's Portfolio Manager System to report each school building's ENERGY STAR[®] Performance Rating, each program further normalizes and examines comparisons among like building types on the basis of six additional energy parameters. This paper presents the full, real world picture of energy use and cost from these schools in many different formats. Use is broken down into electric versus heating fuel. Heating use is normalized both by size and by heating degree days. Cost is normalized by size and by student. Differences among elementary, middle, and high schools are shown. Trends in student density, electric demand, and levels of air-conditioning and computer use are discussed. Finally, the paper expounds on the following areas experienced and observed by each program:

- Defining normalized energy parameters used for comparison
- Marketing campaign
- Database development & report enhancement
- Results:
 - Correlations among and within program datasets
 - Real monthly energy costs observed per fuel type
 - Energy performance of repeat schools/districts
 - National Recognition

Introduction

This paper presents the whole-building energy consumption and cost data from K-12 Schools benchmarked across four states: New York – NYSERDA, New Jersey – New Jersey Board of Public Utilities, Pennsylvania – PPL Electric Utilities, and New Hampshire – New Hampshire Public Utility Commission. The data has been compiled and entered into a single, proprietary database known as, the *Building Energy Performance in Schools* (BEPS) system, thus allowing for “apples-to-apples” comparisons among different states’ data. TRC Energy

Services (TRC) has and continues to conduct rigorous evaluations of all building information and utility billing data provided by each school. Ensuring the accuracy and completeness of data is of paramount importance for any comparative analyses. Table 1 displays the current program totals to date through the end of February 2012:

Table 1. Current Overall Benchmarking Program Metrics per Organization

Organization	Program Duration	Number of Districts	Number of Schools	Total Square Footage (sf)	Number of Students	Total Annual Energy Budget
NYSERDA	2003 – Present	239	1,038	94,061,000	495,498	\$ 138,286,884
New Jersey Board of Public Utilities	2008 – Present	35	179	16,853,000	108,227	\$ 32,504,989
PPL Electric Utilities	2009 – 2011	65	292	27,376,000	160,826	\$ 38,959,410
New Hampshire Public Utility Commission	2010 – 2011	50	201	13,332,000	78,769	\$ 19,207,462
Totals:		389	1,710	151,622,000	843,320	\$ 228,958,745

(Vadney, Overall Program Metrics by School Year)

This amount of current, real world, regional building energy information from facilities with the same single end use has never before been collected and publicly reported. The most widely recognized readily available collection of building energy data to date comes from the U.S. Energy Information Administration’s (EIA) Commercial Building Energy Consumption Survey (CBECS). The EIA collects a sample dataset from a wide range of commercial buildings across the entire nation every four years. In 2003, the CBECS national data sample consisted of 5,215 buildings (<http://205.254.135.7/EMEU/cbecs/2003sample.html>). These buildings encompassed 14 different principal building activities, one of those being Educational Activity (EIA 2006). This paper’s primary goal is to introduce the overall energy usage data from program participating K-12 Schools, explain the efforts involved in obtaining the information, and discuss initial correlations and trends observed. This data is not intended to replace or supersede the data reported through CBECS. Since each of these four K-12 School energy benchmarking programs was voluntary and not mandated throughout the applicable populations, the resulting data may be affected by self-selection bias. Additional data mining and analysis of the entire dataset is planned.

Program Overview and Procedure

Each of the four K-12 School benchmarking programs was developed to address unique issues facing the energy consumers within each organization’s particular market. The objective of any utility benchmarking program is to inform the building administrator(s) about their facility’s energy efficiency at any given point in time. TRC designed a common Energy Benchmarking Report format aimed at providing districts/schools with the following:

1. An understanding of the energy consumption and cost trends for each school building
2. An understanding of how each building compares to other K-12 school buildings both locally and nationally.
3. A means to identify opportunities for improving operations and reducing costs
4. A means to identify technical and funding resources to help improve the school
5. A heightened awareness of the environmental impact energy decisions may have on the surrounding community.

TRC’s BEPS system was designed with simplicity in mind, much like the U.S. EPA’s Portfolio Manager System. The initial goal of the program was to affect the maximum number of school buildings by minimizing the amount of district/school personnel time required to compile and submit the necessary information to benchmark. As such, a basic set of building characteristics including those needed to fulfill the minimum inputs set by EPA’s Portfolio Manager along with only one complete years’ worth of utility billing data were required to participate in the programs. There is no requirement to provide a specific 12 month report period. Districts are notified and encouraged to continue their participation for each 12 month period following its baseline benchmark. The BEPS system accepts any and all fuel types ranging from electricity to natural gas, fuel oil, propane, kerosene, renewable energy sources, steam, and even wood. Throughout the years, the system has become increasingly streamlined with no greater enhancement than the enabling of the ENERGY STAR® Program’s Automated Benchmarking System (ABS). ABS allows approved benchmarking service providers to link their custom energy databases directly to Portfolio Manager. This upgrade bolstered program participation by reducing the time required to produce finalized school reports.

The primary dataset selected for examination within this paper includes K-12 School energy consumption data from buildings within each of the four states over the twelve month period of July 2009 – June 2010. This twelve month period was selected because it captures the most building data across all four programs. The July-June twelve month period is also relevant because it coincides with the school budget year observed by schools within the four states. The dataset contains 288 school buildings from 67 school districts. All of the buildings were eligible to receive an ENERGY STAR® Performance Rating via Portfolio Manager. In addition to examining the distribution of these energy efficiency ratings, six principle normalized metrics were analyzed. These six include Site Energy Use (kBtu/sf), Electric Use (kWh/sf), Maximum Electric Demand (W/sf), Heating Energy Use (kBtu/sf), Weather Adjusted Heating Energy Use (Btu/sf/HDD), and Energy Cost (\$/sf & \$/Student). School buildings that utilized electricity to power their primary heating systems were included within the total metrics including Site Energy Use and Energy Cost; however, these buildings were excluded from the Electric Use, Maximum Electric Demand, Heating Energy Use, and Weather Adjusted Heating Energy Use metrics.

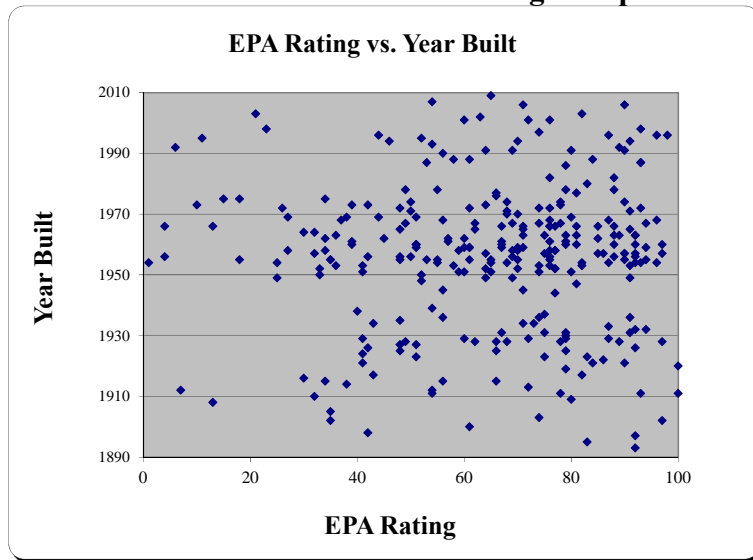
Findings & Discussion of Results

Table 2. Overall ENERGY STAR® Performance Ratings within Dataset

Total Number of Buildings Observed (N)	Number of Buildings with Rating ≥ 75	Number of Buildings with Rating ≥ 50	Mean (Average) Rating	Median Rating	Standard Deviation
288	118	220	65	69	22

The first metric of interest focused on was the ENERGY STAR® Performance Ratings. The range of scores covered all possible ratings from 1-100. The median performance rating was 69, indicating that over the reporting period of: July 2009-June 2010 the majority of the school buildings benchmarked across the four program territory outperformed their Portfolio Manager model-predicted annual energy consumption. We then looked for possible correlations among different data categories. A common misperception among school administrators for each of the four programs was that the age of a building certainly has a major effect on its energy efficiency. Figure 1 graphically displays the results of the comparison between the Year Built vs. EPA's Performance Rating:

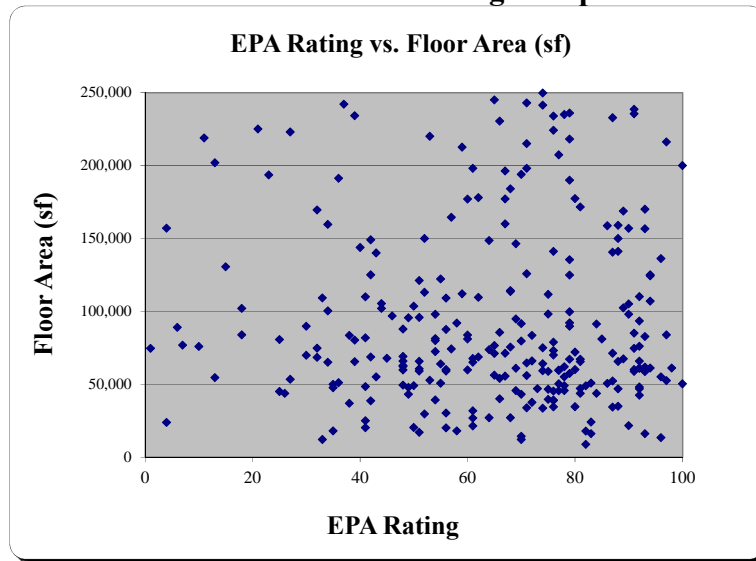
Figure 1. EPA ENERGY STAR® Performance Rating Compared to Year Built Data



(Vadney, Universal Dataset)

The dataset exhibits no such correlation between a building's age and its energy efficiency as evaluated by EPA's Portfolio Manager System. A similar lack of correlation is observed when using normalized site energy use as the independent variable. Another possible correlation tested was whether a building's size has a notable impact on its EPA energy efficiency rating. Figure 2 shows the analysis graphically:

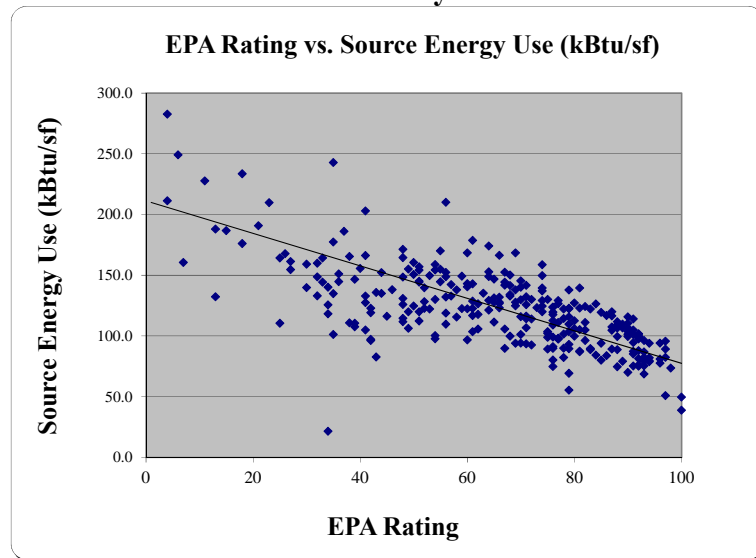
Figure 2. EPA ENERGY STAR® Performance Rating Compared to Building Size Data (sf)



(Vadney, Universal Dataset)

The dataset again proved to exhibit no correlation between the size of a building and its energy efficiency rating. We also tested the verity of Portfolio Manager’s claim that the performance ratings display an indirect relationship when compared to annual Source Energy Use (kBtu/sf). Figure 3 confirms the indirect relationship observed within our dataset:

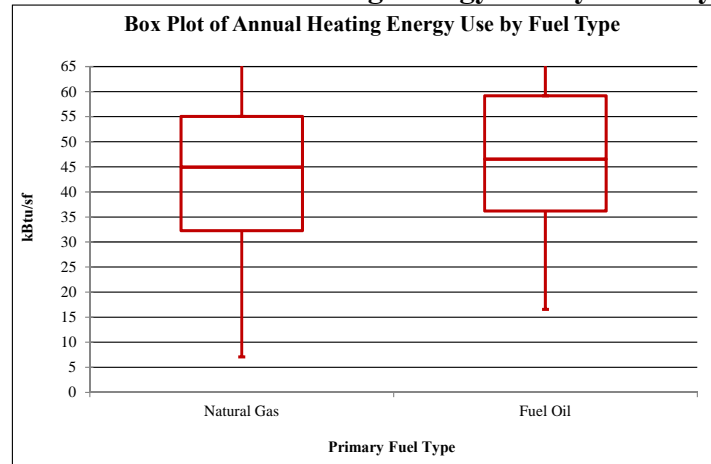
Figure 3. EPA ENERGY STAR® Performance Rating Compared to Source Energy Use Intensity



(Vadney, Universal Dataset)

The dataset was also separated on the basis of primary heating fuel type consumed onsite in an attempt to view differences in annual normalized heating fuel use between schools that consumed natural gas and those that burned fuel oil. Based on the medians of each group, the schools that consumed natural gas exhibited 4.6% lower annual heating fuel use. Figure 4 presents the observed results graphically:

Figure 4. Box Plot of Annual Heating Energy Use by Primary Fuel Type



(Vadney, Universal Dataset)

Table 3, below, shows the minimum, lower quartile, median, upper quartile, and maximum values that went into the creation of Figure 4.

Table 3. Box Plot Values from Figure 4. – Annual Heating Energy Use

Primary Heating Fuel Type	Number of Observations	Minimum (kBtu/sf)	Lower Quartile (kBtu/sf)	Median (kBtu/sf)	Upper Quartile (kBtu/sf)	Maximum (kBtu/sf)
Natural Gas	217	7.07	32.26	44.92	55.05	299.80
Fuel Oil	50	16.55	36.17	46.53	59.15	110.86

(Vadney, Universal Dataset)

Next, the dataset was separated by School Type (Elementary, Middle, & High) to investigate whether any major differences among the three educational building types could be identified. We compared each school type grouping on the basis of Median EPA Performance Rating, Median Site Energy Use, Median Electric Use, Median Weather Adjusted Heating Energy Use, and Median Energy Cost per Square Foot. The resulting metrics are presented in Table 4 below.

Table 4. Universal Dataset: Median Energy Parameters per School Type

Type of School	Number of Observations	EPA Performance Rating	Annual Site Energy Use (kBtu/sf)	Electric Use (kWh/sf)	Weather Adj. Heat Energy Use (Btu/sf/HDD)	Energy Cost (\$/sf)
Elementary	177	66	67.3	5.7	7.9	1.30
Middle	40	71	58.9	6.5	6.0	1.38
High	46	71	70.8	8.0	7.6	1.35

(Vadney, Universal Dataset)

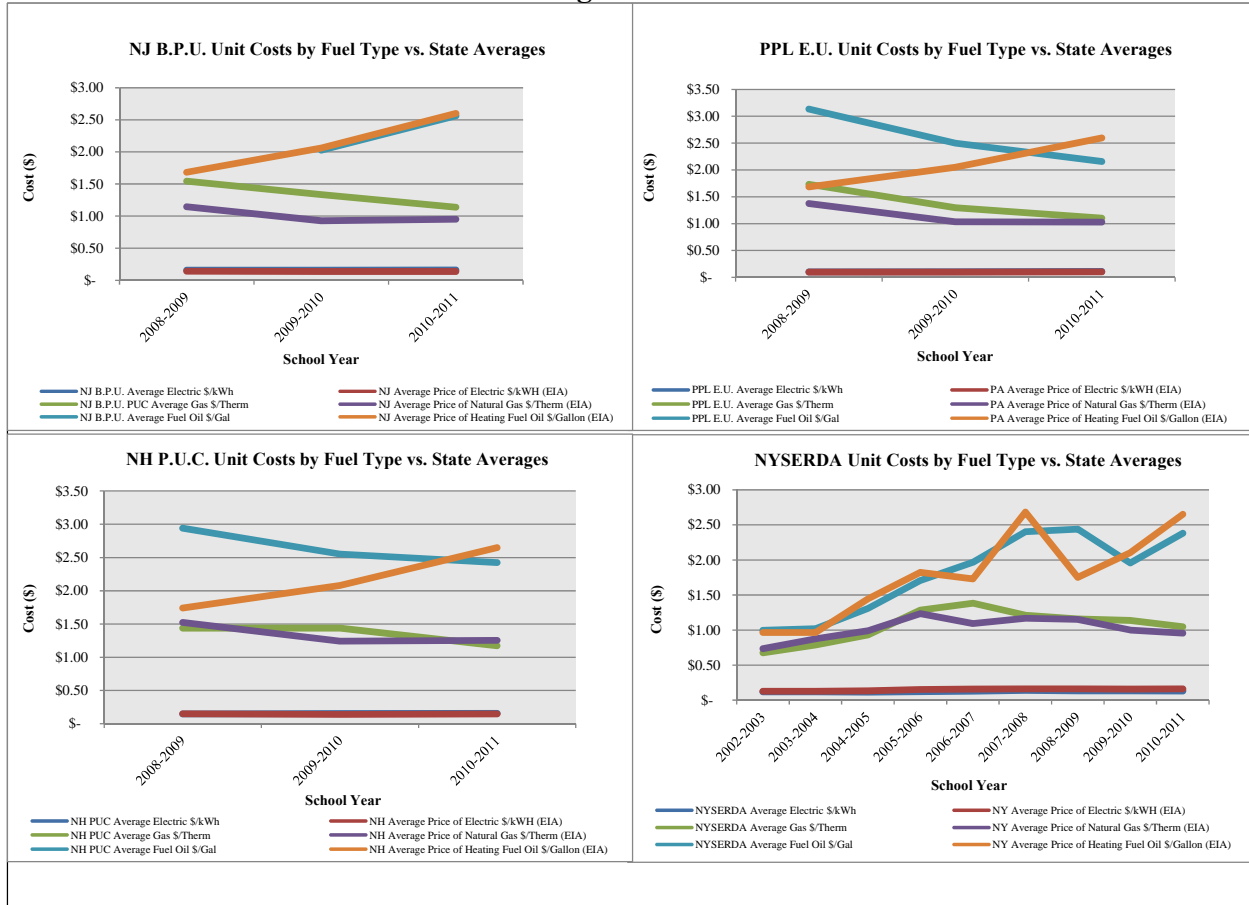
The better than national “average” median EPA Performance Ratings listed in Table 4 were to be expected given the initial focus placed on the metric. To reiterate, the median Rating for the entire dataset was 69. The most interesting discovery within the breakdown analysis of buildings by school type is that among the three types, Middle Schools (MS) exhibit significantly

lower annual site energy use and weather adjusted heating fuel use. Three building operating characteristics: Weekly Operating Hours, Months Used, and Open Weekends failed to explain these differences among school types. The majority of the Middle Schools evaluated (over 70%) responded in the affirmative that they were open on the weekends. This percentage was in between the positive respondent percentages of High Schools (HS) (85%) and Elementary Schools (ES) (51%). The median weekly operating hours observed within the MS data was 10 hours higher than the median within the ES data and only fractionally below that of the HS data. The median for number of months that the buildings are operated within the MS dataset also fell in between that of the other two school types. Each dataset contained a statistically significant number of buildings; however, the possibility of unforeseen sample bias cannot be ruled out without further study.

Overall Database Analysis

The annual unit energy cost data was evaluated over each of the four programs and tracked over time. As part of this analysis, the annual average unit energy costs for electricity, natural gas, and fuel oil were noted for every school year (July-June) covered by the programs and compared to the state average unit energy costs reported by the EIA over the same time periods. The results are shown on the next page in Figure 5. The unit price sold to commercial consumers as listed by the EIA was used for both electricity and natural gas. The EIA's reported natural gas unit cost had to be converted from dollars per thousand cubic foot to dollars per therm. In order to arrive at dollars per therm, the reported unit cost was divided by a conversion factor of 10.29. The EIA's wholesale price of heating fuel oil was utilized for the purposes of this comparison as well. The vast majority of the program unit energy costs trends correspond to the unit costs per fuel of those reported through the EIA. Minor deviations within the trending may be explained by differences in rates paid by the schools being analyzed.

Figure 5. Program Average Unit Energy Costs per Fuel Type Compared to Statewide Averages over Time



(EIA 2012; Vadney, Overall Program Metrics by School Year)

We also investigated the benchmarking results of Repeat Schools over the entire program periods to determine whether there was any impact on their most recent year’s benchmark of annual energy consumption compared to their baseline year. In order for a school building to be classified as a Repeat School, the building would have to have been benchmarked on at least two separate occasions. For example, if a school benchmarked three years’ worth of data covering the period from January 2007 – December 2009 in its initial year benchmarked it would need to have updated the data at a later date either for the period of Jan. 2010 – Dec. 2010 or Jan. 2010 – Dec. 2011; if the school only provided three years’ worth of data in its initial year benchmarked it would not be considered a repeat school. We also set a criteria that Repeat Schools must be eligible for a Portfolio Manager Performance Rating and that their baseline square footage on record matched that of their most recent year’s benchmark. These criteria eliminated any school that was below 5,000 square feet in size, any buildings that were part of a campus (master-metered), and any buildings that may have undergone capital improvement projects that altered the building size. The remaining sample size included 338 school buildings. Tables 5a-5c show the results of the overall analysis:

Table 5a. Baseline Year Benchmarks Vs. Most Recent Year Benchmarks: Total Annual Site Energy Use of all Repeat Schools

Baseline Site Energy Usage (kBtu)	Most Recent Site Energy Usage (kBtu)	Energy Reduction (kBtu)	Percent Change
2,855,445,194	2,586,708,595	268,736,599	-9.41 %

(Vadney, Performance of Repeat School Buildings)

Table 5b. Baseline Year Benchmarks Vs. Most Recent Year Benchmarks: Total Annual Source Energy Use of all Repeat Schools

Baseline Source Energy Usage (kBtu)	Most Recent Source Energy Usage (kBtu)	Energy Reduction (kBtu)	Percent Change
5,222,868,112	4,801,011,169	421,856,943	-8.08%

(Vadney, Performance of Repeat School Buildings)

Table 5c. Baseline Year Benchmarks Vs. Most Recent Year Benchmarks: Total Annual Greenhouse Gas (GHG) Emissions of all Repeat Schools

Baseline GHG Emissions (Mt CO ₂ e)	Most Recent GHG Emissions (Mt CO ₂ e)	GHG Emissions Reduction (Mt CO ₂ e)	Percent Change
275,328	252,082	23,246	-8.44%

The National Average eGrid Carbon Factor was used in calculating the GHG Emissions from electric consumption
(Vadney, Performance of Repeat School Buildings)

Our analysis shows a near nine and a half percent drop in the annual total site energy use of K-12 schools that have conducted benchmarks on at least two separate occasions. This collection of 338 schools has together eliminated the annual total Greenhouse Gas Emissions equivalent to the annual emissions from the energy use of 2,013 homes. (<http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>)

School Benchmarking & Recognition

Successful school energy benchmarking programs have the ability to concisely report building consumption and cost data in a manner that is easily understood, allowing for the information to be disseminated quickly amongst decision makers from all backgrounds. The key to effectively inform school district administrators is the design and layout of the benchmarking report. Figure 6a. displays the top portion of the current, main summary page from the active programs' benchmarking report. This section of the report presents the basic building characteristics which were used along with the actual monthly utility billing data to benchmark the school facility. The school's Portfolio Manager Results are displayed within the upper right hand corner of the report page and the building's environmental impact is shown just below the Portfolio Manager Results. The pie charts within the next section of the page show the school building's breakdown of annual energy use and cost.

Figure 6a. Sample Benchmarking Report: Building Performance Summary (Top Half)

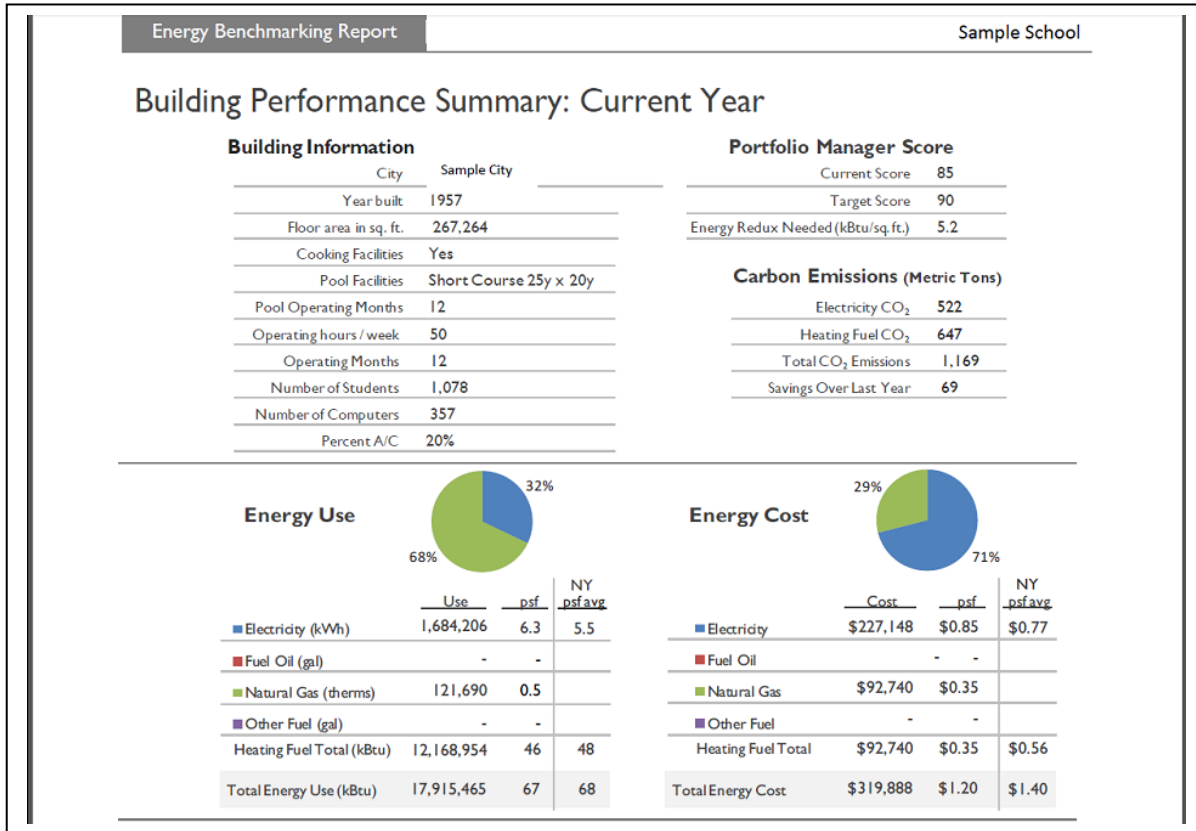


Figure 6b. Sample Benchmarking Report: Building Performance Summary (Bottom Half)

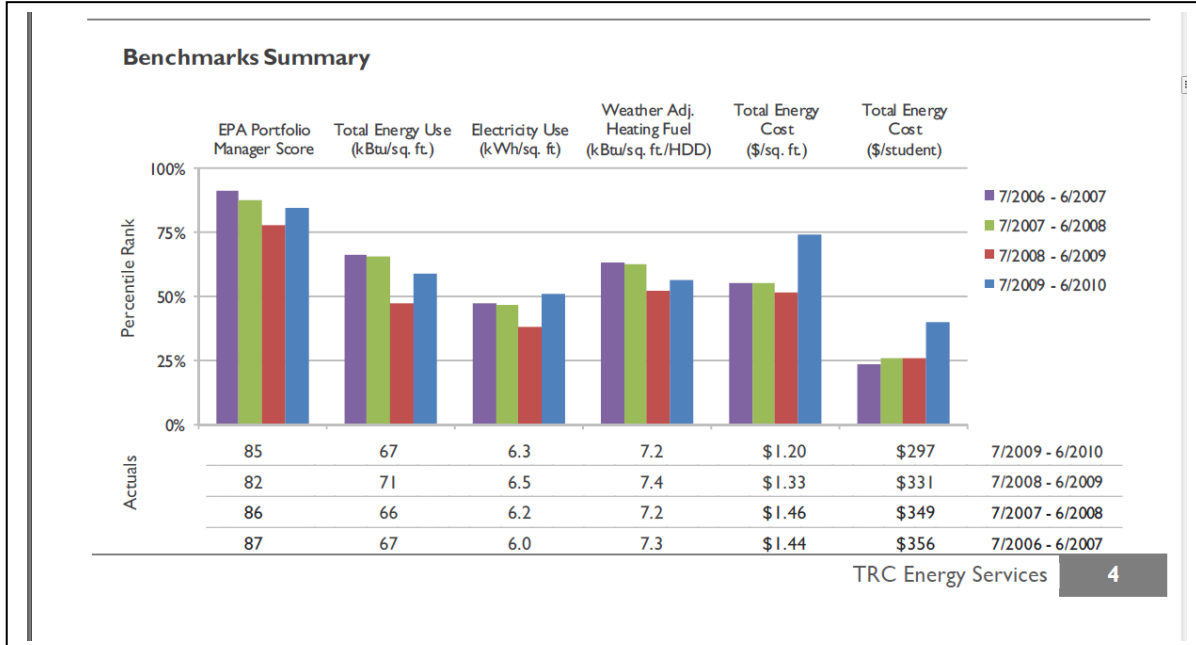


Figure 6b displays the bottom portion of the report page which presents the school building's percentile ranks within the program for each of the six major energy performance metrics analyzed.

Producing reports that market themselves through dynamic visual aids and attributes will not only engage the reader to take action but will be presentable to a district’s board of education. The four programs mentioned within this study, periodically upgraded their report templates to provide the most up to date building information, rebate program summaries, and graphics. These actions kept the benchmarking programs current and encouraged both new and repeat participation. Although the benchmarking report is a valuable marketing tool, not one of these notable programs relied solely on their deliverable to spread the word about the program.

The marketing campaigns of these major school benchmarking programs required the organizations to be motivated and willing to alter their campaigns as dictated by their target populations. Actions included but were not limited to:

- Press releases - via both print and television
- E-mail Blasts
- Direct Mailings
- Websites
- Newsletters
- Case Studies
- Partnerships with professional organizations - such as state chapters of ASBO and School Boards Association
- Even Cold Calling was utilized in some cases to jump start participation

Sharing news of success stories and best practices among school districts was and continues to be the most influential means of recruiting new participants. The U.S. EPA’s ENERGY STAR® Recognition Program provides national appreciation to facilities exhibiting excellence in whole building energy efficiency. Three of the four benchmarking programs included complete application funding for participants whose buildings achieved eligibility for the ENERGY STAR® Label for Buildings. Table 6 displays the recognition totals for all the participating school districts.

Table 6. National Recognition Achieved through the ENERGY STAR® Program

	ENERGY STAR Labels	ENERGY STAR Leader Districts	ENERGY STAR Leader Awards
Totals	429	18	34

(Vadney, Overall Program Metrics by School Year)

Conclusions

The data presented here from three state funded benchmarking programs in New York, New Jersey, and New Hampshire along with data collected throughout PPL Electric Utilities service territory in Pennsylvania attempts to provide a preview of the detailed, aggregated energy usage and cost data that has been collected since 2003. Further data collection as well as additional analysis of historically recorded school building energy information from the BEPS system will assist in validating some of the findings presented within this report. K-12 Schools are of predominant concern nationally because their energy efficiency has the power to affect all tax payers. Informing our school administrators through low cost or no cost energy benchmarking programs about the performance of district buildings will serve as a means to identify under performing schools in need of improvement. Up to date consumption and cost

data allows for informed decisions to be made which in turn will increase the overall energy efficiency throughout all of the nation's schools.

References

Greenhouse Gas Equivalencies Calculator. 2011. U.S. Environmental Protection Agency. 4 May. 2012. <http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>

U.S. Energy Information Administration. 2006. 2003 Commercial Buildings Energy Consumption Survey (CBECS): Detailed Tables. http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set19/2003pdf/alltables.pdf. Washington, D.C.: U.S. Energy Information Administration.

U.S. Energy Information Administration. 2006. 2003 Commercial Buildings Energy Consumption Survey (CBECS): Sample Design. <http://www.eia.gov/emeu/cbecs/2003sample.html>. Washington, D.C.: U.S. Energy Information Administration.

U.S. Energy Information Administration. 2012. New Hampshire Price of Natural Gas Sold to Commercial Consumers (Dollars per Thousand Cubic Feet) <http://tonto.eia.gov/dnav/ng/hist/n3020nh3m.htm>. Washington, D.C.: U.S. Energy Information Administration.

U.S. Energy Information Administration. 2012. Weekly New Hampshire No. 2 Heating Oil Wholesale/Resale Price (Dollars per Gallon) http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPD2F_PWR_SNH_DPG&f=W. Washington, D.C.: U.S. Energy Information Administration.

U.S. Energy Information Administration. 2012. New Jersey Price of Natural Gas Sold to Commercial Consumers (Dollars per Thousand Cubic Feet) <http://tonto.eia.gov/dnav/ng/hist/n3020nj3m.htm>. Washington, D.C.: U.S. Energy Information Administration.

U.S. Energy Information Administration. 2012. Weekly New Jersey No. 2 Heating Oil Wholesale/Resale Price (Dollars per Gallon) http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPD2F_PWR_SNJ_DPG&f=W. Washington, D.C.: U.S. Energy Information Administration.

U.S. Energy Information Administration. 2012. New York Price of Natural Gas Sold to Commercial Consumers (Dollars per Thousand Cubic Feet) <http://tonto.eia.gov/dnav/ng/hist/n3020ny3m.htm>. Washington, D.C.: U.S. Energy Information Administration.

- U.S. Energy Information Administration. 2012. Weekly New York No. 2 Heating Oil Wholesale/Resale Price (Dollars per Gallon)
http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPD2F_PWR_SNY_DPG&f=W. Washington, D.C.: U.S. Energy Information Administration.
- U.S. Energy Information Administration. 2012. Pennsylvania Price of Natural Gas Sold to Commercial Consumers (Dollars per Thousand Cubic Feet)
<http://tonto.eia.gov/dnav/ng/hist/n3020pa3m.htm>. Washington, D.C.: U.S. Energy Information Administration.
- U.S. Energy Information Administration. 2012. Weekly Pennsylvania No. 2 Heating Oil Wholesale/Resale Price (Dollars per Gallon)
http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPD2F_PWR_SPA_DPG&f=W. Washington, D.C.: U.S. Energy Information Administration.
- U.S. Energy Information Administration. 2012. Retail Sales of Electricity by State by Sector by Provider, Back to 1990 (Form EIA-861) > <http://www.eia.gov/electricity/data.cfm>. Washington, D.C.: U.S. Energy Information Administration.
- Vadney, M. 2012. "Overall Program Metrics by School Year.xlsx".
- Vadney, M. 2012. "Performance of Repeat School Buildings.xlsx".
- Vadney, M. 2012. "Universal Dataset.xlsx".