# Evaluating Energy Usage in K-12 Schools from a Statewide Perspective

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## ABSTRACT

How do you benchmark more than 900 school buildings and then audit the energy inefficient buildings in less than a year? And then how do you implement suggestions identified in the audit to realize energy savings? Those were the questions asked by the state of Nebraska when they released a request for proposals (RFP) in April 2011. They asked engineering teams to put together proposals to accomplish the above tasks. The team of the Schemmer Associates and Waldinger Corp. was selected from several respondents to provide services. The team worked closely with the Nebraska Energy Office (NEO) to devise and execute a plan that would meet the expectations of the NEO and provide actionable information for the schools involved in the study. The execution portion was removed from the project, which allowed school districts to work with engineers and contractors of their choice. Beginning in early July, every school district in the state was invited to participate in the program. Approximately 60% of the school districts responded to the initial requests for utility bills. Of the approximately 979 buildings, 57 received investment-grade audits and were given energy master plans to enable them to cut their utility costs at their own pace.

## INTRODUCTION

The question still remained, how to perform benchmarking and audits on every K-12 building in the state. The solution was to leverage power from the NEO to obtain utility bills, then to enter them as quickly as possible into the Energy Star Portfolio Manager. The team allowed two months for schools to either submit their bills or to decline. From the submitted data, the challenge was to pick the least energy efficient schools without focusing too much on one area. The team broke up the areas by congressional districts and tried to select buildings with approximately the same square footage in all districts. What resulted was a diverse list. Funding for the project was paid for by the American Recovery and Reinvestment Act (ARRA) funds through the State Energy Program (SEP). The funds had to be allocated prior to April 30, 2012, and the program limited the amount of time available and how the project was procured.

## PROJECT PLANNING AND EXECUTION PHASES

A kickoff meeting was held between the design team and the NEO to plan the process and set milestones to meet the federal government requirements for use of the ARRA funding prior to the deadline of April 30, 2012. At the time, the Schemmer/Waldinger team had approximately 10 months to accomplish the project before the funds expired. It was agreed that the NEO would send an initial letter to all school districts followed shortly by a letter from the Waldinger/Schemmer team explaining the intent of the project and asking for their participation and cooperation.

### Phase I

The first phase of the project was to set benchmarks for all participating schools in Energy Star and to generate an Energy Star score for each building. The team generated a questionnaire asking each district for pertinent information such as square footage, number of freezers, coolers, the number of computers, and so forth, to accurately benchmark each building. Each district was asked to fill out the questionnaire for each building and provide 18-24 months of energy bills for each building as well. The team allowed a two-month window for districts to respond, and set a deadline of September 7, 2011, to cut off the utility data collection, determine the total Energy Star score for each building, and select buildings for investment-grade energy audits. Just over 70% of the districts participated; some districts already had Energy Star accounts, which they shared with the NEO and the Waldinger/Schemmer team. Individual accounts were set up for each school district. A central, master account was set up in Energy Star as a single file for all data from all districts for the state to review, and as a tool for each district to continue tracking their energy consumption. The importance of this component will be explained later. Figure 1 is a scatter graph showing each building on the Energy Star scale. This graph shows a wide operating disparity among buildings, including those in the same district. The graph shows that the schools tend to be in the upper half of the energy scores rather than the lower half of efficiency, indicating that most of the schools were average to fairly efficient, barring bad data. The data were checked, all numbers were verified, and all scores were determined to be accurate.

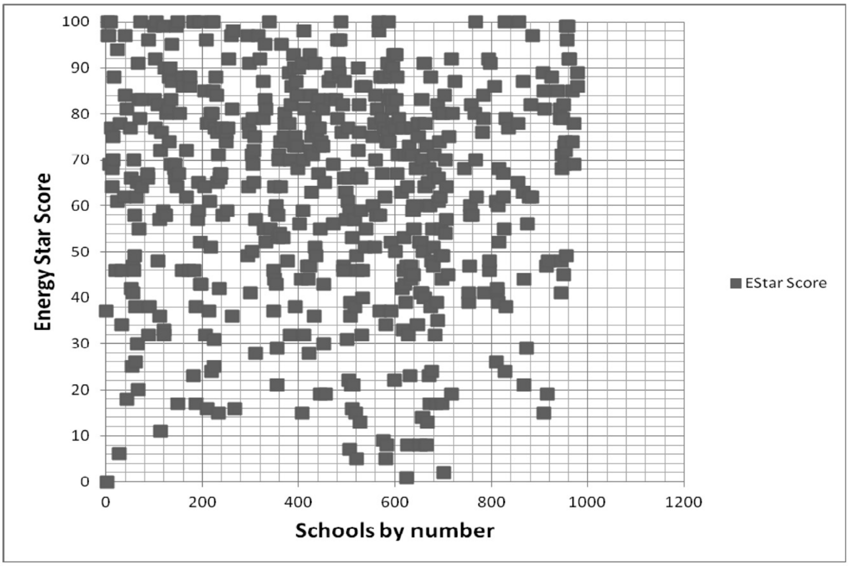


**Figure 1**

Based on this wide disparity among buildings, and other political pressures, the team decided to separate the schools into three individual zones, coincidently divided by congressional districts. We then looked at the poor energy efficiency performers in each zone and picked an equivalent number of buildings to perform audits on. The cut off was an Energy Star score of 32 and below to receive an audit; however, a couple of schools with scores of 34 were added to the audit because of geography or proximity to a building receiving an audit, which also helped equalize the number of buildings in each zone. The locations of buildings receiving audits are imposed on a Nebraska map in Figure 2.

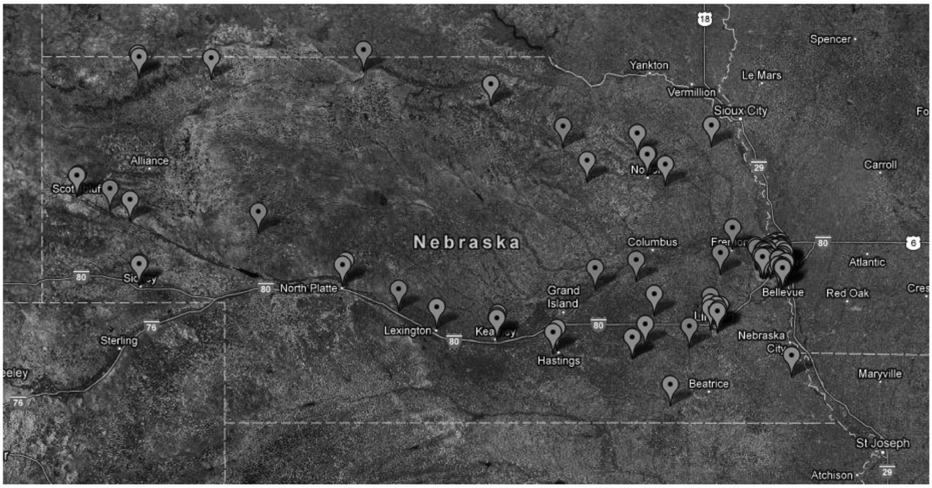


**Figure 2**

The NEO received a printout of the Energy Star report and a CD of all of the reports. The master account set up on the Energy Star website allowed the NEO to continue to monitor each district and determine whether they continued using the Energy Star tool. From the master account data, the team prepared a list for Phase II audits.

**Phase II**

Once the schools for the audits were selected, we contacted each superintendent to discuss the intent of our investigation and the benefits for the buildings receiving the audits. To maximize our investigation time on site, we used data obtained from Phase I. In general, we spent from 2-6 hours in a facility cataloging equipment, identifying energy economic modeling (EEM) figures, and making plans for follow-up measurements. We spent a good amount of time speaking with the building maintenance personnel and users to find out what they liked and what equipment was a maintenance challenge.

The building was again benchmarked against the commercial buildings energy consumption survey (CBECS) document in addition to Energy Star to better understand where potential savings might be. This allowed us to focus on certain utilities and the types of equipment that could yield the most savings. Also, if some data appeared to be anomalous, it allowed the team to re-examine the data to see where potential savings might be or where an error may have been made. Figure

3 shows the CBECS analysis and how the buildings were benchmarked by size, age, and use and an average kBtu/sf determined from the tables. This information was invaluable during the site visit portion of this phase.

The calculations portion was done individually per EEM. The calculations were a mixture of spreadsheet calculations and energy models to determine costs and savings. A basic scope of work narrative was written up to allow pricing of each individual EEM. The contractor sec-

| | | HIGHLAND ELEMENTARY | CBECS 2003 - Zn 2 | CBECS 2003 - Zn 2 | CBECS 2003 - Zn 2 |
|---|---|---|---|---|---|
| Building Data | Building | Highland | Education | Year Built | Bldg Area |
| | Yr. Built | 1982 | - | 1980-1989 | - |
| | Sq. Ft | 57,022 | - | - | 50-100k SF |
| Elec Usage | Ann. Avg. kWh | 1,187,270 | - | - | - |
| | Ann. kWh/ft² | 20.8 | 8.0 | 20.0 | 12.6 |
| | Ann. kBtu/ft² | 71.0 | 27.3 | 68.2 | 43.0 |
| Gas Usage | Ann. Avg. Therms | 18,045 | - | - | - |
| | Ann. Therms/ft² | 0.3 | - | - | - |
| | Ann. CF/ft² | 31.0 | 49.4 | 59.3 | 41.5 |
| | Ann. kBtu/ft² | 31.6 | 50.4 | 60.5 | 42.3 |
| | Tot Ann. kBtu/ft² | 102.7 | 77.7 | 128.7 | 85.3 |

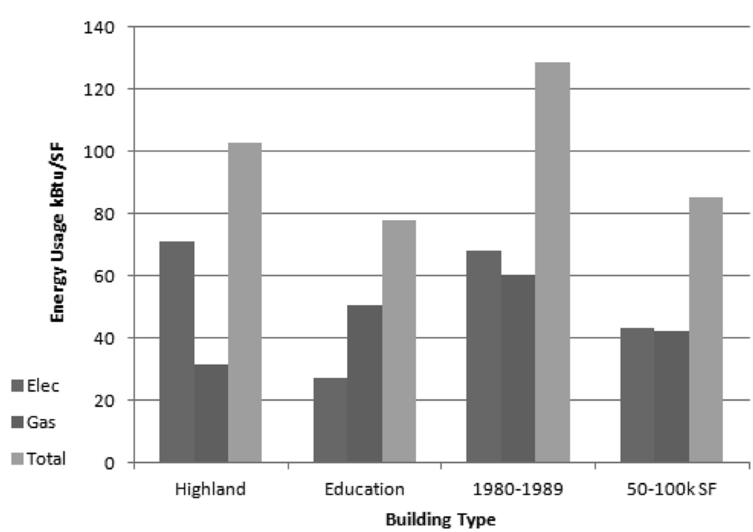


**Figure 3**

tion of the team was able to provide accurate cost pricing. The costs and savings were then presented in a master plan format that allowed the owners to pick and choose which projects they wanted to pursue. Figure 4 is an example of the cost and savings matrix.

This exercise was repeated on the 57 buildings selected for the audits. Those audits were completed, turned into the NEO, reviewed and updated. As of this writing, the documents have been turned over to individual school districts for their use.

**Conclusion**

In the end, the owners of more than 600 buildings received updated Energy Star accounts to track energy usage in their facilities that will allow them to identify low performers and implement energy improvement projects to decrease their utility consumption. A total of 57 buildings received investment-grade audits, which provided the building owners with master plans for how to reduce energy consumption. In the end, the Waldinger/Schemmer team identified a wide array of energy efficiency measures that resulted in $1,822,203 in savings, while costing

| EEM Num. | EEM Description | KWH Saved | Therm Saved | Yearly Savings | Initial Cost | Simple payback |
|---|---|---|---|---|---|---|
| 1 | Add DDC controls. Remove pneumatics | 1089 | 0 | $60 | $100,000 | None |
| 2 | Convert Steam to hot water | 2300 | 11,494 | $6,793 | $100,000 | 14.7 |
| 3 | Gym lighting retrofit | 8280 | 0 | $455 | $4,000 | 8.8 |
| 4 | Reduce kitchen exhaust/make up | 946 | 716 | $467 | $1,000 | 2.1 |
| 5 | Demand Control Ventilation in Gym units | 411 | 348 | $224 | $3,000 | 13.4 |
| 6 | Indirect solar thermal domestic hot water | 0 | 668 | $387 | $10,000 | 25.8 |
| 7 | Multi-zone to VAV conversion. | 315,740 | 36,449 | $38,506 | $150,000 | 3.9 |
| 8 | Install new chiller | 30,380 | 0 | $1,671 | $200,000 | None |
| 9 | Install dedicated gymnasium unit | 55,319 | 0 | $3,043 | $25,000 | 8.2 |
| 10 | Install VFD's on all pumps and fans | 66,900 | (-369) | $3,465 | $20,000 | 5.8 |
| 11 | Rezone for better control | 0 | 0 | $0 | See EEM#7 | None |
| 12 | Install high efficiency motors | 24,751 | 0 | $1,361 | $10,000 | 7.3 |

**Figure 4**

$26,668,125 to implement, a simple payback of 14.6 years. With the low interest, loans described in the payment schedule will allow the project to pay for itself plus interest in 16 years utilizing just the energy savings as payment. All of this work was performed from July 2011-April 2012. With good communication, planning, and teamwork, we were able to deliver a timely, quality product to the NEO as well as provide the audited school districts with a road map to cut energy consumption in their buildings.

The NEO increased incentives for these districts, offering 1% interest loans to school districts to perform the energy efficiency measures that had been identified in the report. To qualify for the low interest loan, they need to keep the Energy Star account up to date and continue to allow the NEO to have access to it.

To date, it is unknown to the author if any schools have implemented the energy conservation measures, and no measurement or verification data were available to verify the numbers. The NEO will track energy consumption and could provide data on actual performance on any buildings for which they have provided loans.

Note: All references to Energy Star are copyrighted by the U.S. Department of Energy and refer to the Department of Energy's Energy Star program.

**Bibliography**

1 Commercial Building Energy Consumption Survey (CBECS), 2003; U.S. Energy Information Administration; U.S. Department of Energy.
2 Phase I and Phase II reports submitted to Nebraska Energy Office (NEO) for data used in report.
3 Google Maps.

**Acknowledgements**

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ABOUT THE AUTHORS

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**Russ Zellmer**. Russ Zellmer is a member of AEE and ASHRAE and has more than 13 years of experience in mechanical estimating, construction and energy services. Russ served as production project manager and coordinated the logistics that went into executing this project. He also led an audit team and was instrumental in quality control and assurance. You can contact Russ at rzellmer@omaha.waldinger.com.