Case Study

Successful Low Cost Energy Efficiency and Cost Control Strategies for a Rapidly Growing School District

Phil J. Tornelli, BSET, MBA, CEM

ABSTRACT

This article describes energy and cost-saving initiatives implemented over a 10-year span between the Volusia County School System and FPL. Opportunities were identified and addressed in three focus areas: 1) Control and equipment improvements in new schools and in retrofits; 2) Advanced metering with operating changes; and 3) Behavioral alterations and motivations to encourage users to take an active role in savings programs.

BACKGROUND

Volusia County, located in the heart of Florida's central east coast, is a rapidly growing area comprised of sixteen municipalities, including famed Daytona Beach. Volusia is Florida's 10th largest school district, educating about 65,000 students from kindergarten through high school. FPL, the nation's leading utility in energy conservation and one of the top five U.S. utilities in load management, serves 37 of the county's 73 public schools.

FPL and the Volusia County School system (VCS) worked together over the past 10 years to develop a standardized process to improve energy efficiency and reduce energy costs in their shared environment of rapid population growth. Successful efforts in the FPL-served schools were expanded and continue to be implemented in all Volusia schools, although this article includes only the savings in the 37 schools served by FPL.

RESULTS

The original 37 schools served by FPL are saving $600,000 per year in energy costs, of which approximately $400,000 are energy savings and $200,000 are rate savings. Additionally, the school system received more than $220,000 in incentives from FPL to lower the up-front costs of installing energy-saving technologies. Resulting kWh savings were as high as 27 percent in the most successful locations. A holistic approach that looked at existing equipment, new construction designs, and behavioral modifications was the cornerstone of the plan. This approach was seen as most effective since VCS previously planned to add high-cost energy saving equipment. Another integral part of this project was the installation and use of advanced metering at 21 schools identified as representative of the others. Profile data from these meters was used to develop energy saving strategies that later were implemented systemwide.

Dramatic changes occurred within the school system during the project. They included size as well as code changes. The school district's square footage served by FPL grew by more than one million square feet from 3.6 million in 1997 to 4.8 million square feet last year. Energy usage also rose by more than 10 million kWh. In 1997, FPL provided 47 million kWh per year for an average of 13.1 kWh/Sq-Ft/yr. Ten years later, those numbers were 59 million kWh per year and 12.3 kWh/Sq-Ft/yr. These numbers continued to improve this year, with the system running at a rate of 11.5 kWh/Sq-Ft/Yr for the first seven months of 2008. Meanwhile, changes in building codes called for higher outside air requirements and additional indoor air quality (IAQ) improvements. Those changes, which made maintaining even the same energy use per square foot a difficult task, highlight the success of this project.

Note: Much of the savings achieved required little or no additional investment. Savings were achieved solely by monitoring and evaluating school usage profiles, making control adjustments, and then analyzing the effects of recommended changes to equipment settings and operating schedules.

The remainder of this article contains a detailed description, with examples of the key parameters that contributed to making this decade-long initiative such a success. This article also identifies factors that can cause a successful project to fail over time. Finally, this case study can be used as a guide for developing and maintaining a dynamic energy management program based on documented results and lessons learned from various Volusia County schools.

4-STEP PROGRAM

There are four key elements in this energy and cost saving initiative. The first and most essential element contributing to a successful result is to **identify and gain commitment** from various levels of management within the school system. The second is to **measure and analyze** how energy is consumed (advanced metering is needed). Third is a continuing process of **evaluating** usage, usage profiles, and the results of conservation efforts. The final element is the **development of a clear plan** for improvement in new construction, large projects, and existing facilities.

Step One

Understand the Organizational Structure:
Who are the Decision-makers?

Many energy-saving measures and options are available that may be popular but not ideal in a particular application. One key to getting appropriate improvements implemented is to first gain agreement from management that the measures to be selected are cost effective and would not adversely affect indoor air quality or conflict with other operational needs of the school system.

For example, turning off HVAC equipment might lower costs, but could also lead to IAQ problems. Adding too many controls or elaborate technologies may promise savings, but might also cause operational problems by being too complicated for facilities personnel to maintain.

To gain management support, start by learning the organizational structure of the school system. Identify the decision makers and understand which part each person plays in approving and implementing a project.

Exhibit 1 relates to decisions affecting energy projects and conservation efforts within the Volusia County School System. Different decision makers may be involved at different times or for different components of the overall project.

For example, some projects need to start with direction or an order from the superintendent. This is especially important if the project is related to behavioral modification, such as changes to thermostat settings or operating schedules. The superintendent's order then has to be carried out by school principals, who must communicate the order to the teaching staff and to the building operators, known as field management technicians (FMT).

Other changes, such as those affecting technologies, controls, and maintenance schedules, need to be authorized by the executive director of facilities before being passed on to the implementing departments. The energy manager, operating in parallel with department heads, works with a support staff. The staff may include engineers, utility representatives, accounting and billing support personnel, project managers, and others. It's the energy manager's job to establish the direction of conservation efforts and communicate the results of those efforts to all involved.

Therefore, it's imperative that the appropriate decision-makers be consulted and buy-in assured, or opposition neutralized, prior to attempting to implement any changes.

Step Two

Analyze usage and assess current conditions

It is extremely important when setting up an energy management

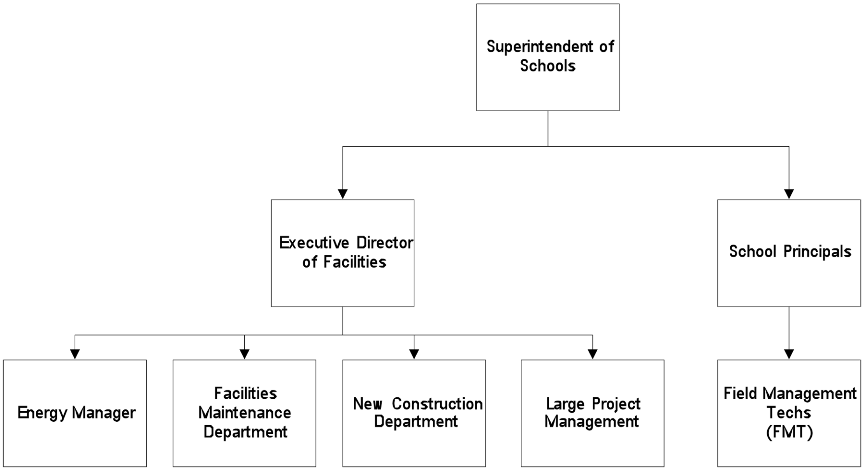

Exhibit 1. Organizational Structure

program to use all available measurement and analytical tools to assess existing conditions and document savings. The VCS case used several methods and tools to conduct this evaluation.

The first task is to obtain or create a detailed analysis of the electric utility bills. An Excel spreadsheet was developed including historical kWh usage, kW peak demand, and load factor percentage* by month and year, for each account and each campus. This report was then stratified: The highest energy-using facilities and those with the highest load factor appeared at the top.

High load factor can indicate higher operating hours and longer run times. In this case, school facilities with tight control schedules and standard operating hours usually had load factors in the 30 percent to 40 percent range. Those with higher load factors were thought to have a higher likelihood of equipment operating after hours. Based on these assumptions, those schools found to have load factors above 50 percent were selected for further analysis.

The chart in Exhibit 3 helps show how load factor can be such a powerful and effective indicator of which schools have the most potential for energy savings. The chart displays the actual hourly, weekday, kW demand profile for one high school evaluated during the project. Note that the original profile represents the facility's profile prior to energy efficiency improvements and control changes. It was both higher

Exhibit 2. Load Factor

Load Factor Calculation Example

Load Factor	=	kWh/Mn	/	kW Peak Demand x Billing Days/Mn x 24 Hr/Dy
33.6%	=	kWh/Mn	/	1600 kW x 31 billing days x 24 Hr/Dy

Note: School facilities often are used for many purposes outside normal school hours, so it's important to review each school's total operating schedule before concluding that an energy saving opportunity exists. Assumptions based solely on a school having a higher than average load factor may prove inaccurate.

*The load factor percentage is defined as kilowatt hours consumed in a monthly bill, divided by the maximum usage possible based on the facility's peak kW demand. The maximum is found by multiplying the peak kW demand billed for the month by the number of hours in the billing period.

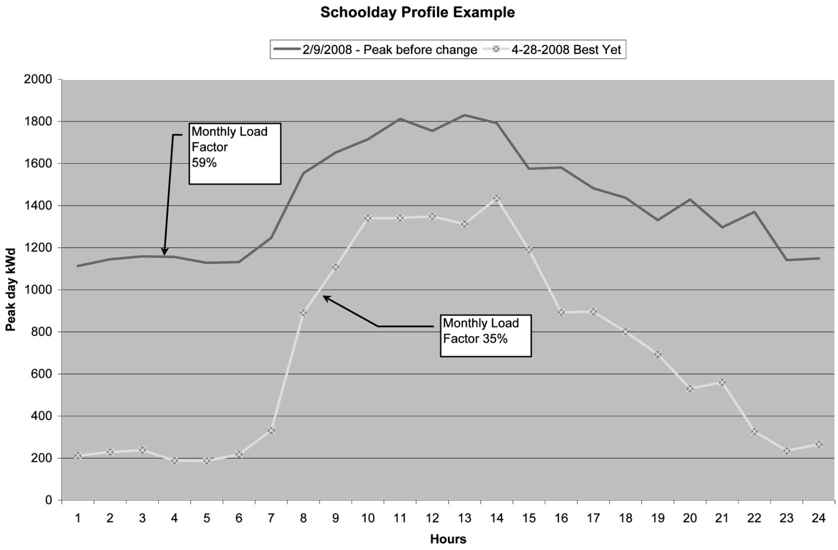

Exhibit 3. Load Factor and What it can Reveal

and flatter than the post-changes profile. The original profile displays high kW demand at night and during hours clearly outside a normal school schedule. Load factor percentage was calculated at 59 percent for that particular month. Once energy efficiency improvements and recommended control changes were implemented, load factor dropped to 35 percent.

Energy Use Index (EUI)

The EUI is another valuable analysis tool. It is an index of energy use/area/time. In the VCS case, the index was defined as kWh per square foot of conditioned space per year. It has the advantage over other analysis tools in that it is easy for the average person to explain and grasp. However, its drawbacks are that an EUI can be difficult and time consuming to put together. Some factors that hinder use and accuracy of the EUI are:

- Schools can have multiple electric meters that must be identified and consolidated on paper.

- Some schools use more than one energy source. If gas or other fuel is used for heating, it might be necessary to categorize those schools and compare them differently.

- Obtaining consistent and accurate square footage numbers for conditioned spaces within each campus can be difficult since some schools include covered walkways, gyms, and other buildings that may not be conditioned in the square footage numbers they report.

Energy Surveys

Once the data were stratified, the next step was to conduct energy surveys, starting with those facilities identified as having the highest load factor and EUI. The surveys addressed two key objectives. First, surveys were used to identify possible energy saving opportunities, and second, to determine possible causes for higher-than-average load factor and/or energy consumption.

Advanced Metering

An essential and integral part of the program was the use of advanced meters, which can provide detailed information such as hourly energy use that standard meters cannot. For the most effective level of analysis, advanced measurement and metering with the ability to gather hourly/interval profiles are necessary. However, the FPL-VCS project team found a low-cost solution **to the initial installation of** advanced meters in all locations.

Few VCS schools had interval metering at the project's inception: most did not. To obtain a better understanding of each school's usage profile while also minimizing installation costs, a sample approach was devised. Project team members identified a representative example of each school type and advanced meters were installed at those facilities, bringing the total to 21 facilities with advanced metering. Later, a VCS policy change was implemented to ensure that advanced metering would be installed in all new schools or during major renovations to existing schools.

Note: Exhibit 4. Federal building metering guide. Advanced metering was recognized as being of such high value in conservation efforts that a guide was developed by the federal government recommending its use, where applicable, as a standard in federal buildings.

Step Three

Evaluate usage, usage profiles, and calculate results

With advanced metering in place and current conditions evalu-

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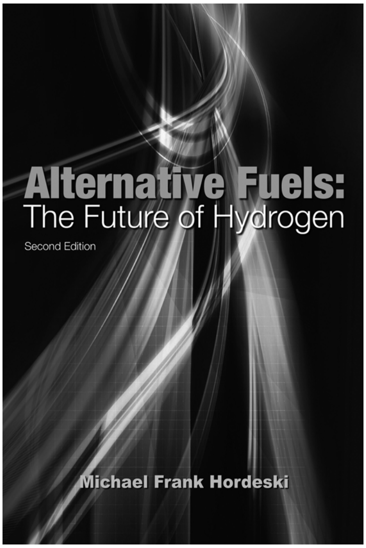

Michael F. Hordeski

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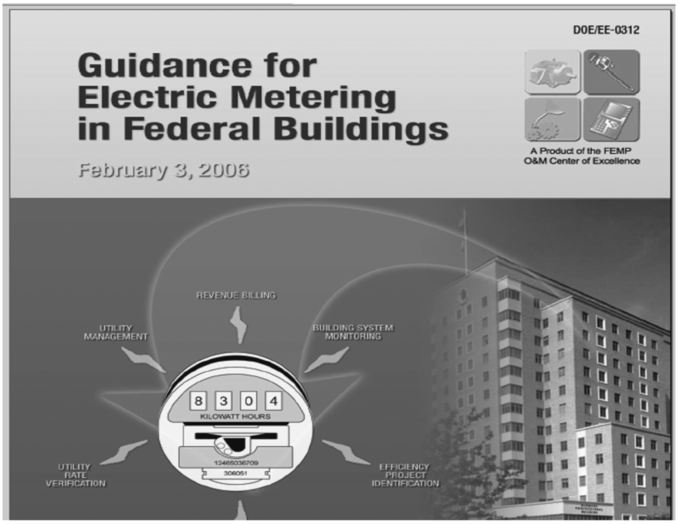

Exhibit 4. Federal Building Metering Guide

ated, the next step was to look for opportunities to improve and implement changes indicated by the data analyses and energy surveys:

- Technology upgrades.
- Behavioral modifications.
- Control system changes.
- Alternate utility rates (Note: It's essential that the energy manager understand utility rates for this portion of the project to succeed. An educational component may be required in some situations).
- Metering consolidation.

1. Technology Upgrades

Over the project's 10 years, the Volusia County school district adopted many changes to its energy-consuming systems. During that decade, beginning in 1997, the school system received more than $220,000 in incentives and rebates from FPL. Some of the equipment improvements are shown here.

- High efficiency chillers.
- High efficiency air conditioners and heat pumps.
- High efficiency lighting—T-8 lamps, compact fluorescent lamps.
- Energy recovery ventilation.
- Demand control ventilation.
- Variable speed drives.

- Control additions and improvements in capabilities.
- 24-hour monitoring for energy management.
- Reflective roof coatings.
- Direct expansion ac to chiller conversions with variable air volume.

2. Behavioral Modifications

The school board and superintendent must support the efforts. The VCS superintendent issued a directive to all staff members, which also included motivational incentives, such as school recognition, as rewards. The directive called for teachers and other staff members to make a conscious effort to turn off lighting, turn up HVAC thermostats, turn off computers, close doors when the AC was on, and integrate other energy-conserving and cost-saving habits to support energy conservation efforts.

Concurrently, a detailed analysis of building systems also was conducted by the FMTs working with the VCS's energy manager. That collaboration led to many scheduling and control changes that would further reduce energy consumption. These measures are described in the next section.

3. Control System Changes

Improved control capabilities that were added in new schools/additions and remodeling projects gave them the ability to tighten operating schedules resulting in significant energy savings.

Exhibit 5A shows an example of a middle school with a typical energy use profile *prior* to the project. Exhibit 5B shows a similar school *after* both scheduling modifications and promoting conservation in the schools through behavioral changes occurred. It's important to note that it took several meetings with the school's assistant principal, their FMT, the energy manager, and their FPL representative to tighten operation before reaching the Exhibit 5B profile.

Also, a regular review process should be conducted to ensure changes are maintained. One observation was that there was a tendency for the school to return to a more relaxed operating schedule if the energy manager and/or utility representative stopped monitoring and providing feedback to the FMT and the assistant principal. It proved equally important to continue to recognize the school staff for its efforts.

Weekend usage analysis also offered savings opportunities. Exhibit 6 shows hourly usage plotted over an entire month for the same middle school. It further demonstrates the value in having hourly and

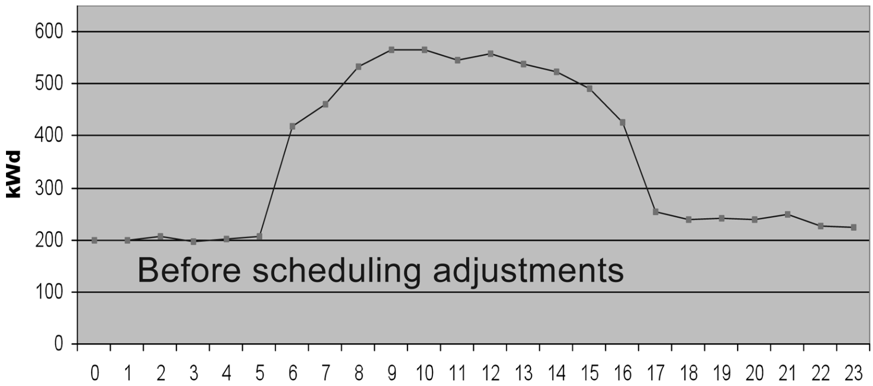

Exhibit 5A. Typical Middle School Profile before Scheduling Adjustments

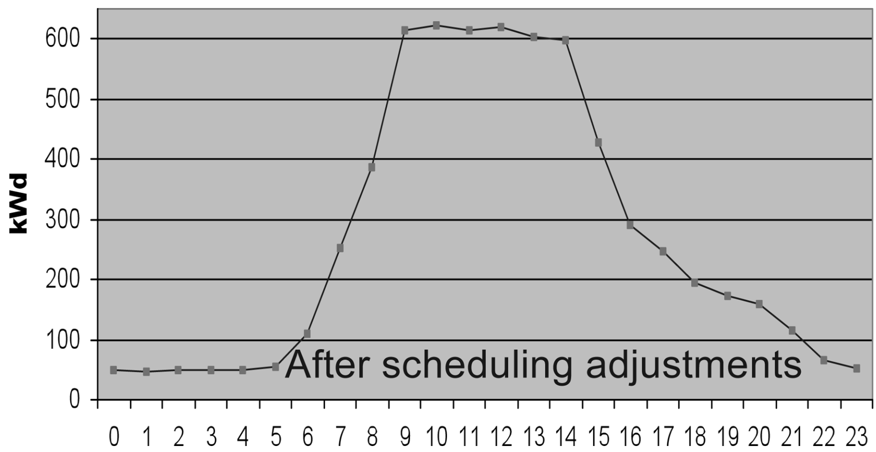

Exhibit 5B. Typical Middle School Profile after Scheduling Adjustments

daily kW demand data. It clearly shows the demand profile is lower on the weekends. This supports the contention that the FMT has adjusted controls to reduce weekend use, and when combined with Exhibit 5B's improved weekday profile, confirms that they are working diligently to minimize unnecessary equipment operation.

4. Alternate Utility Rates

After the school kW demand profiles were brought in line with school operating schedules, the next step was to evaluate alternate FPL utility rates for cost-saving opportunities. FPL offers a seasonal time-of-

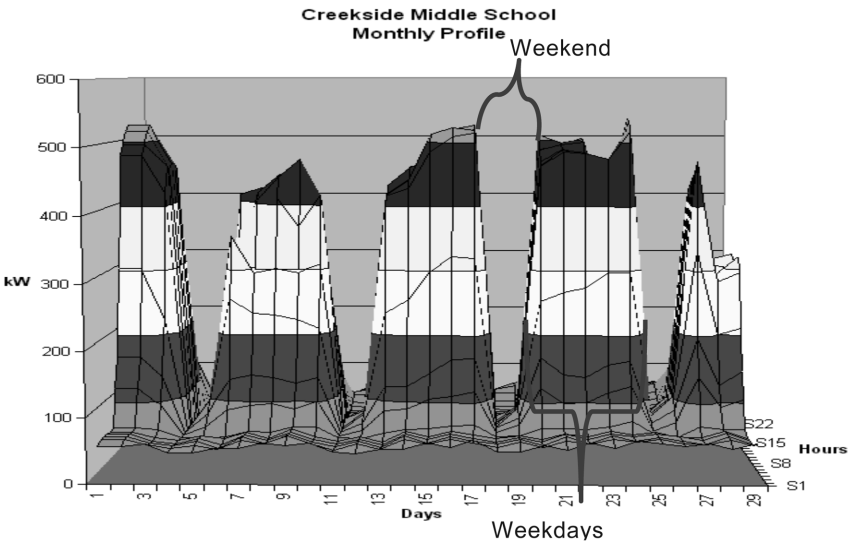

Exhibit 6. Weekday and Weekend Profile

use rate that only charges for summer kW demand if it occurs between the weekday hours of 3 p.m. and 6 p.m.

Exhibit 5A, titled "Before Adjusting Schedule," indicates peak demand had not dropped significantly before 3 p.m. and the school would not be a good candidate for the rate. However, the improved building profile shown in Exhibit 5B, titled "After Adjusting Schedule," shows significant reduction in kW demand before 3 p.m. As a result, the school could now save by a rate change.

Exhibit 7, below, illustrates this point. Lessons learned at the middle school were applied at all similar locations. Note that Exhibit 7 is the profile of a high school that also shows demand reduction before 3 p.m. As a result of these findings, and the analysis of the 21 sample schools with advanced metering, it was believed that most schools within the system were now operating in a manner that could benefit from the seasonal rate and the rate was changed on all applicable accounts. As of this writing, the Volusia County School system has 62 accounts on this new rate.

Results

In 2007 alone, VCS saved $193,000 from this rate change.

6. Metering Consolidation

Another area of opportunity relating to utility rate structures is recognizing the value of metering consolidation under the right circum-

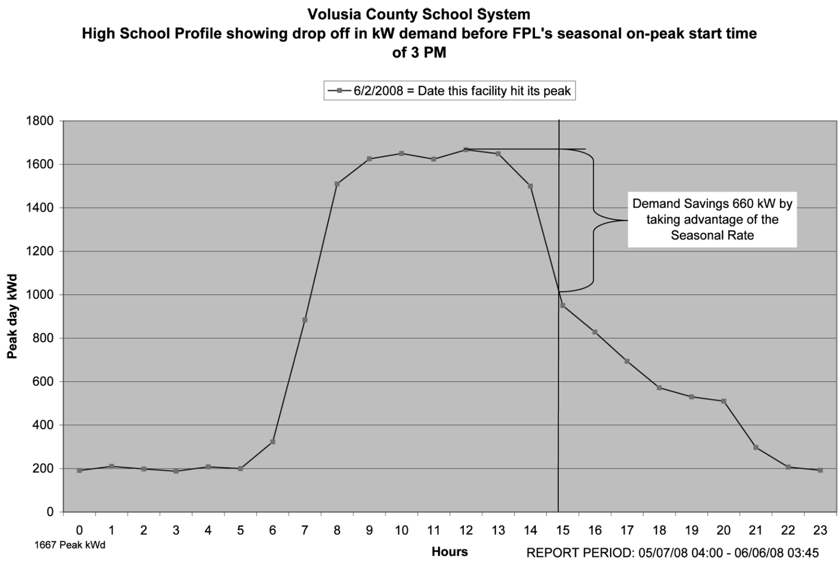

Exhibit 7. Control Adjustments lead to Seasonal Rate Savings Opportunity

stances. In the VCS case, many schools had expanded over time and, as a result, some campuses had multiple electric utility meters. This prompted two observations regarding schools with multiple meters:

1. A school may be on a less favorable utility rate and/or unable to qualify for alternative or larger customer class rates.

2. In the VCS case, larger accounts garnered more attention from the administration, and this increased awareness level helped speed important energy improvement projects through the approval process.

Load Diversification

Meter consolidation also can provide another advantage: utilizing electrical load diversity. When electrical loads are operated at different times under the same metered account, certain benefits may result. For example, in Florida, heating systems might operate in the morning and cooling systems in the afternoon. Because kW demand charges are based on the meter's peak measured demand for the month, two meters could mean two peak demand charges, one for the morning heating peak and one for the afternoon cooling peak. If metered together, it is more likely that the peak would only be for the higher of the two loads or at most the summation of their instantaneous peaks. Therefore, there may be a savings if loads such as these were combined into one metered account.

Another example relates to sports field lighting that would operate in the evening after the majority of campus demand has dropped off. If this lighting is separately metered, considerable savings could result from rewiring and consolidating the load under the campus main meter.

Exhibit 8 illustrates this benefit by showing savings at another VCS high school campus. Sports field lights at this campus operated for years under a separate meter and paid a separate kW demand charge. Rewiring and consolidating was identified as a potential improvement, but the first costs were too high to implement as a solo project. When the school added a large addition, rewiring and meter consolidation of the sports field lighting were incorporated into the project. By consolidating these loads, VCS is now saving more than $1,800 in kW demand charges each month that the lights are used.

Step Four

Develop a plan for improvement in new construction, large projects, and existing facilities.

The first three steps of the four-step FPL-VCS plan enabled the school system to:

- Recognize the value of energy saving opportunities;
- Identify problem areas;

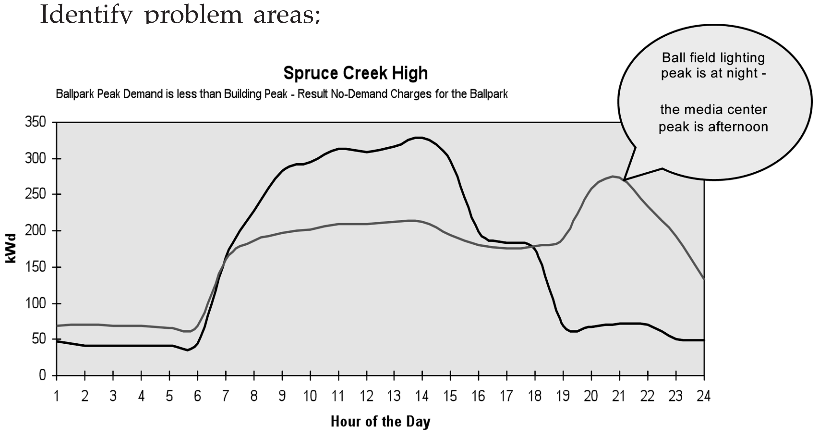

Exhibit 8. Meter Consolidation leads to kW demand saving

- Demonstrate savings;
- Minimize energy costs through utilizing more favorable utility rates.

In step four, a long-term plan was developed to ensure that energy-intensive equipment continues to be upgraded and technologies changed wherever and whenever appropriate. The plan starts with a clearly expressed commitment from the school board and superintendent to fund appropriate projects, encourage energy and cost saving efforts, and recognize successes. Roles and responsibilities are defined, with the energy manager key to continuing success.

The school system's energy manager has the responsibility to work with the operations and design groups to identify additional control needs, technologies, and school designs that improve energy efficiency. Then they all must work together to ensure that these changes are incorporated into the design of future schools and added to existing schools whenever economically justified.

The energy manager also is charged with continuing to promote the benefits of proposed projects, document the savings from ongoing projects and search for new opportunities. This is in addition to the manager's responsibility of continuing to promote behavioral modifications and advertise successful results.

Results of the Successful Low-cost Energy Efficiency and Cost Control Strategies for a Rapidly Growing School District

Figures 9 through 11 display reductions in daily kilowatt hours consumed which resulted from the improvements that were implemented. Note that these schools have been continuously improving their energy profiles throughout the tracking period.

High School Case Study

This high school had the following measures included during construction or added later.

- Meter consolidation—just before construction.
- Added during construction:
  - High efficiency chillers in a central plant.
  - Advanced energy management control systems.
  - High efficiency lighting—T-8 lamps, compact fluorescent lamps.

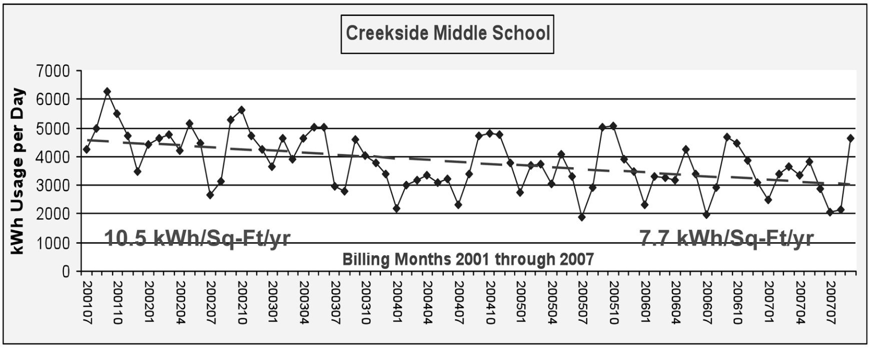

Exhibit 9

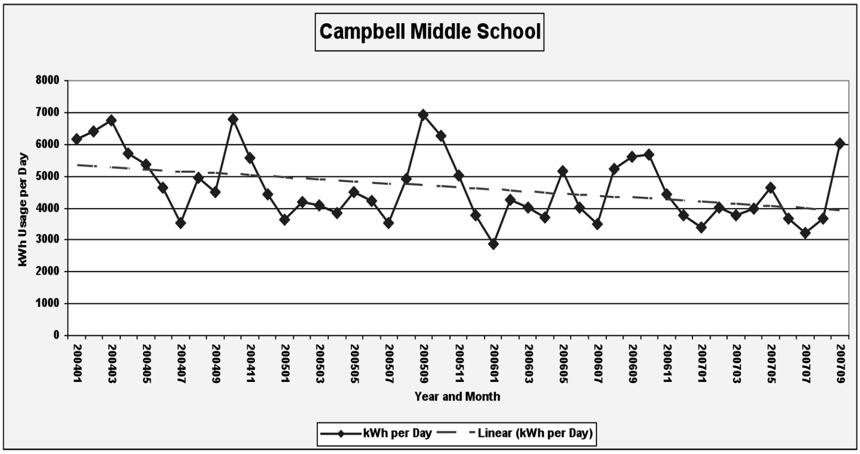

Exhibit 10

  — Energy recovery ventilation.
- Added after construction:
  — Demand control ventilation.
  — Variable speed drives.

Note: A significant lesson learned from this project is the importance of continuous commissioning. Even though this facility had the latest technologies, it still required continuous and concerted efforts to bring all the controls and systems in line with expected consumption.

Gym Improvements

A significant change added after construction was demand control

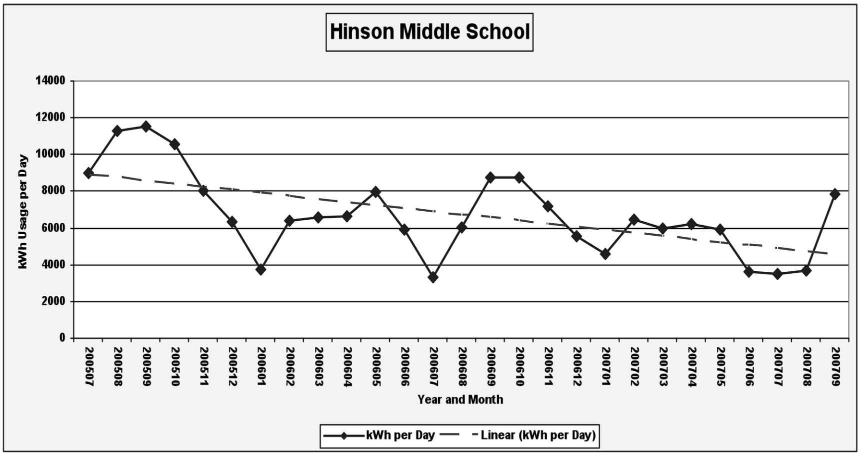

Exhibit 11

ventilation (DCV) in the school's gym/athletics building. This facility comprises almost 60,000 square feet of conditioned space. The original design used a constant volume 75-HP air handler fan with electric resistance reheating. The facility was built with cooling capacity capable of handling large crowds, although most of the time it was used only for physical education classes of 30 or fewer people. As a result, it was difficult to throttle down the cooling system sufficiently to handle low load conditions so the gym often was overcooled. Electric heat was then used to raise the temperature back into a comfortable range. Monitoring of the heaters confirmed they were running much of the time. Proposed modifications to improve system efficiency included installing:

- Variable speed drive (VSD) on the 75-HP fan, lowering fan speed based on proximity to set point.
- Demand control ventilation (DCV) using CO_2 monitoring.
- Controls to allow the energy recovery ventilator (ERV) to raise and lower outside air input based on space CO_2 levels.

These systems allowed the gym's HVAC system to be throttled down to reduce overcooling and eliminate the need for heating to offset the chill. Both the DCV and ERV enabled this cost saving operation to occur while still maintaining proper ventilation and indoor air quality. A combination of this project with other scheduling and operational changes provided the campus with a significant reduction in energy use.

Several building kW demand profiles showing how building performance changed over time as improvements were implemented are displayed in **Figures 12 and 13**. It is important to note that in one month, usage actually increased while adjustments were being attempted. This increase was later associated with a control scheme that caused the gymnasium to return to operating at night after slight changes were made to temperature and humidity settings. Proper control of the system was finally achieved with the addition of the DCV/VSD.

Exhibit 12—kW Demand Profile Improvement Timeline

The most recent and lowest usage profile demonstrates the combined results of all the efforts that have been made to date. These include the continuing adjustments to controls and schedules, the DCV and VSD in the gym, behavioral modifications, and many other energy-saving initiatives.

Exhibit 13—Energy Usage per Square Foot

Note that energy usage has been cut to less than half the original daily usage rate and its usage per square foot has dropped from a high

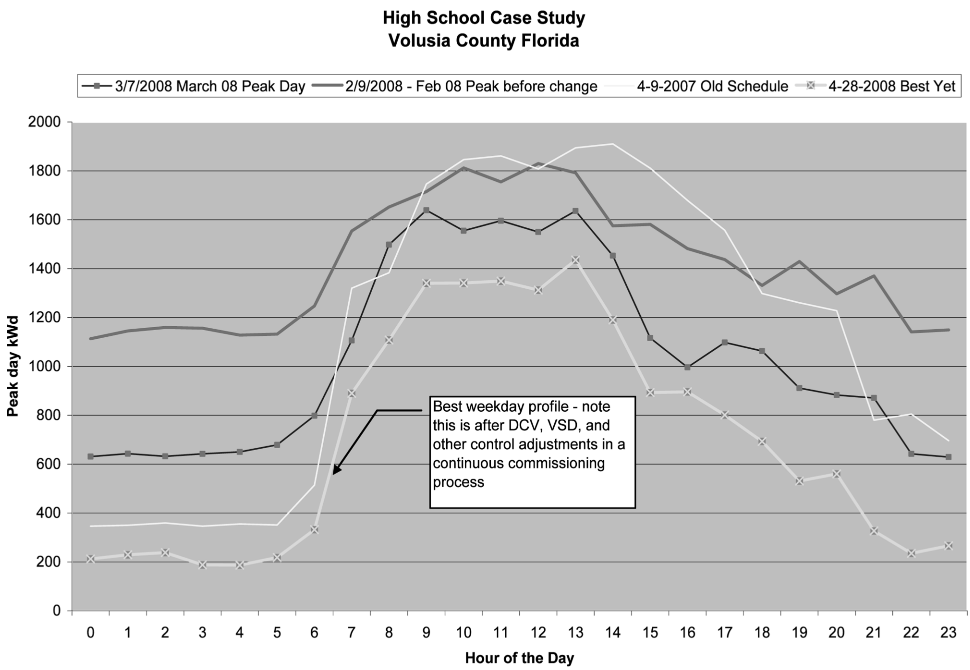

Exhibit 12. High School Case study—Profile changes over time

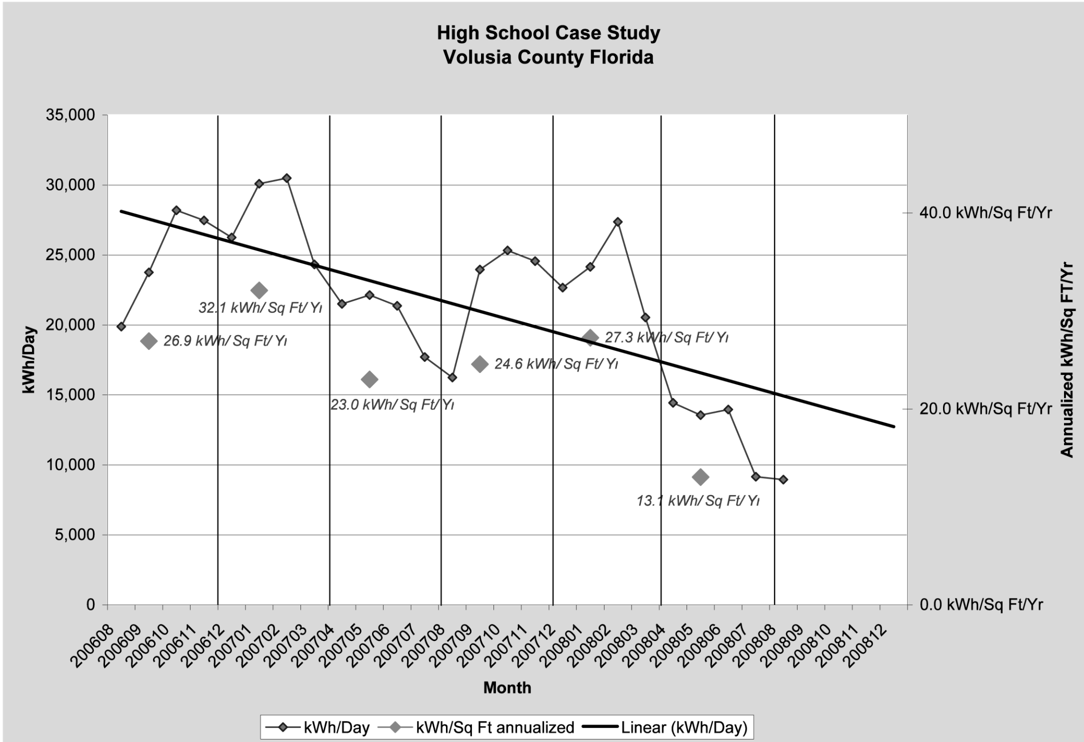

Exhibit 13. kWh usage and kWh/Sq Ft/Yr (EUI) Note: EUI is annually projected based on quarterly results

of 32 kWh/per Sq Ft/Yr (highest quarter when annually adjusted) to just over 13 kWh/per Sq Ft/Yr when annually adjusted for the five months since the DCV/VSD and other changes were implemented.

CONCLUSION

The Volusia County School System is extremely pleased with the results. This has been a very successful program and it is believed to have broad application in other school districts and applicable governmental entities. We believe it is important to let others know of the success of this project and get the word out that it's possible to get great results with concentrated efforts that may include elaborate technologies, but that also produce impressive results with low and no-cost strategies.

Special Recognition:
This report recognizes the efforts of James D. Ermisch, Volusia County School System's coordinator of energy management, for without his direction and hard work to get these projects and operational changes implemented, the school system would have never reached its current level of achievement.

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Phil has more than 25 years of energy management experience at one of the nation's largest electric utilities, consulting with customer segments including educational and governmental institutions as well as commercial and industrial organizations. Mr. Tornelli also has instructed numerous classes addressing energy saving programs, business energy evaluations, and rate savings strategies.

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