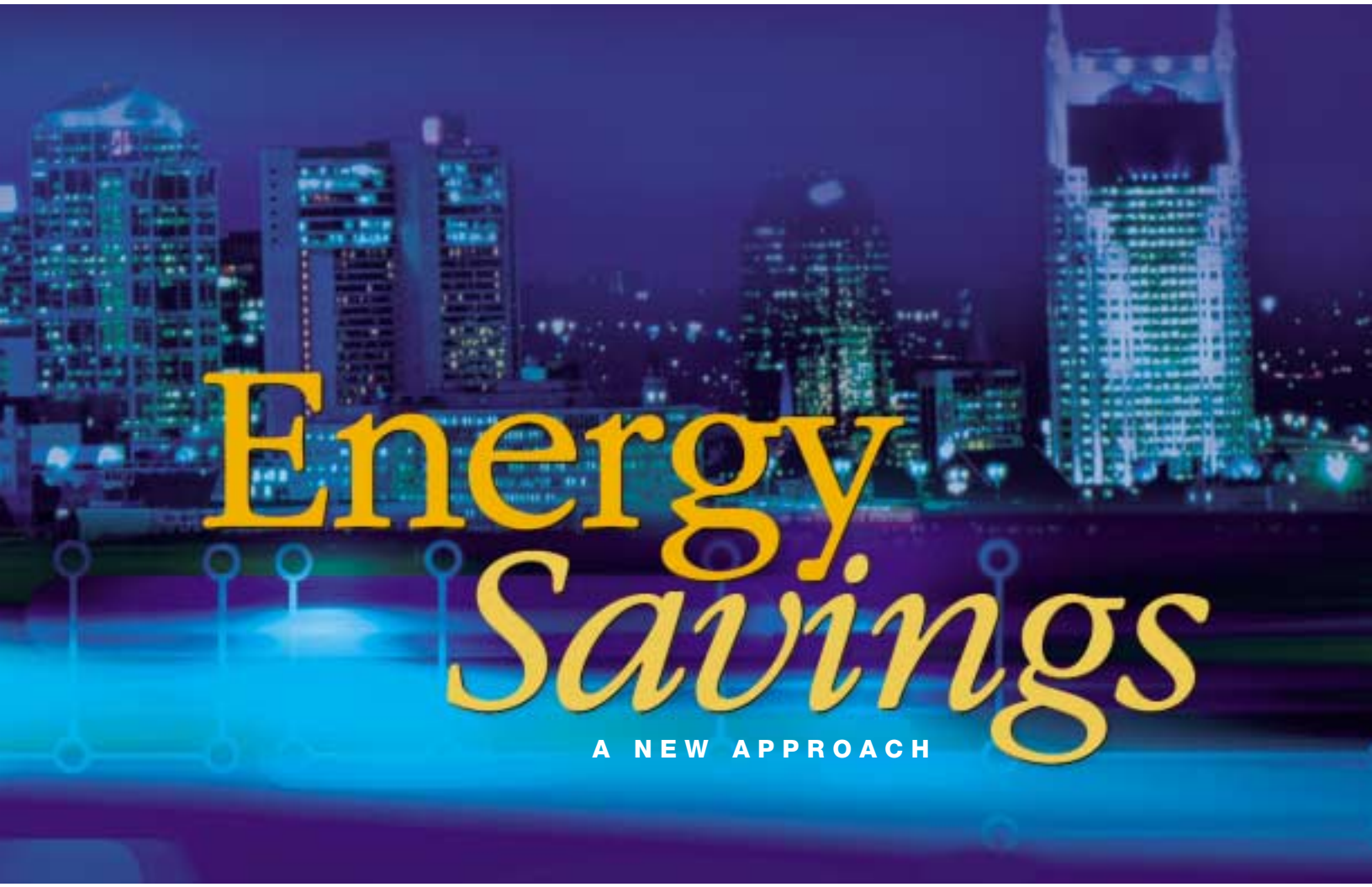

Energy
Savings
A NEW APPROACH

Contents

An energy retrofit at the Andrew Jackson and Rachel Jackson State Office Buildings in Nashville meant huge cost savings for Tennessee and a successful benchmark for future projects.

Like many large buildings completed in the past 30 or 40 years, the Andrew Jackson and Rachel Jackson State Office Buildings in Nashville, Tennessee, required large expenditures of energy—and money—to provide a reasonably comfortable working environment for their tenants. But thanks to a large-scale energy-efficiency retrofit completed in September 2004, the buildings are projected to consume 55 percent less energy than they did two years ago. In addition, the tenants enjoy a greater level of comfort through improved heating, cooling, and building controls and a better lighting system. The State is spending less for more, and that's a success story in anyone's book.

Project goals and objectives

To identify potential energy savings in both the Andrew Jackson and Rachel Jackson office buildings, Nashville Electric Service (NES) and the Tennessee Valley Authority (TVA) worked closely with the State Building Energy Management program (SBEM). The Department of General Services (DGS), TVA, and NES supervised a detailed energy study, completed in 2000, which outlined numerous energy conservation opportunities (ECOs) that could be implemented. Since the two structures share staff, security considerations, and common utilities, it made sense to tackle upgrades in both at the same time.

The Andrew Jackson and Rachel Jackson State Office Buildings in Nashville are adjacent facilities with a combined square footage of more than 620,000 square feet. Existing lighting and HVAC systems were inefficient and costly.

The $4 million Andrew Jackson and Rachel Jackson (or AJRJ) project was designed to pay for itself in less than five years through the projected reduction of energy expenditures alone. Those savings, which amounted to more than $800,000 in annual utility costs, were achieved through a number of ECOs such as improved lighting fixtures and controls, HVAC upgrades, and an energy management system. The savings realized from the project also allowed the State to tackle key safety issues such as fire protection.

In addition, the AJRJ retrofit served as a pilot project for the energy savings performance contract (ESPC) process, laying the groundwork for other State efforts aimed at reducing costs and improving facilities. As energy and maintenance savings increase across the state through the implementation of ESPCs, wasted energy dollars can be redirected to fund more pressing needs.

Background and history

Tennessee pays more than $100 million a year in energy costs for its office buildings and other facilities, and State engineers have long recognized that inefficient heating, cooling, and lighting systems were costing the State a great deal. In 1997, NES and TVA sponsored a preliminary energy analysis for the Andrew Jackson and Rachel Jackson buildings. This initial audit identified potential ECOs and their associated costs and savings. Those measures having the greatest value were selected for further study.

At that time the SBEM group was carrying out some smaller-scale retrofits to the tune of about $70,000 per project, and those efforts were able to reduce energy costs by as much as 50 percent in some buildings. But many factors worked against large-scale retrofits of public buildings. They included the complexities of the budget

The lighting retrofit was among the first upgrades to be completed in the buildings, achieving a 14 percent reduction in energy consumption almost immediately.

The new energy management system allows the facilities staff to obtain immediate feedback on conditions in the buildings, providing tight control that contributes greatly to tenants' comfort and productivity.

process, the complications of competitive bidding, and the lack of standardized contracts.

A more favorable climate for large energy projects emerged in the late '90s. It was created partly by the Center for Energy Efficiency at Middle Tennessee State University, which worked on standardizing the language for the ESPC.

Members of the State's energy management group and TVA presented the idea of working with an ESPC to the Tennessee Department of Finance and Administration, and an agreement was reached to contract for a highly detailed energy analysis of the two office buildings. For this analysis, the State partnered with Nashville Electric Service and TVA's Energy Services Company (ESCO). ESCO managed the energy analysis as well as the installation work. The State agencies involved in the project felt a certain comfort level working with another government agency on a project of this complexity, and they didn't have to worry about finding subcontractors for the installation, which ESCO handled.

Data collection

For the in-depth energy study of the buildings, ESCO contracted with Architectural Energy Corporation (AEC) of Boulder, Colorado, one of the premier energy efficiency companies in the world. AEC analyzed utility data and conducted walk-through audits and interviews with building staff.

To perform a dynamic analysis of the facilities, AEC used short-term diagnostic testing, which employs specialized software and hardware tools to gather and analyze data on the performance of the building systems. Data were collected from throughout the buildings every five minutes for up to three weeks. The information was then downloaded and analyzed, revealing load shapes and diagnostic plots for identification of operational issues.

The energy baselines for the buildings were established using the DOE-2 energy model, a building energy simulation program developed at Lawrence Berkeley and Los Alamos National Laboratories. The program calculates hour-by-hour energy consumption over an entire year using climate data for the location. A detailed description of the building is entered into the program, including occupancy at different times,

lighting, fan and pump schedules, air temperature set points, chilled and hot water supply and return temperatures, and zone temperatures. The study identified 11 cost-effective energy conservation measures with a payback period of less than five years through reduced energy use. The projected savings on utility costs were more than $800,000 a year (see table below).

Development and implementation

Although the potential savings were documented, the project underwent a long, arduous approval process because it represented a new approach to building upgrades and energy efficiency for State government. In March 2003 the State Building Commission gave approval for the work to begin. The objectives were to save energy and money, improve operations, and demonstrate the validity of the ESPC process.

In order to identify the strengths as well as any potential weaknesses with the energy savings performance contract, the delivery order process was employed. Under that process:

- The State, NES, and TVA developed the scope of work and identified construction and financing costs, performance period costs, and annual savings. Monitoring and verification requirements were also identified.
- The final delivery order outlining specific recommendations was reviewed and approved by the State Building Commission staff.
- NES and TVA developed the plans and specifications and performed the work, with oversight and approval by the State's Capital Projects office and the State Architect's office.
- The savings are verified annually by established methods. Any operational deficiencies are corrected by the State, and equipment performance deficiencies are corrected and/or adjusted for by NES and TVA.

"TVA recommended a broad scope of work to achieve the energy savings," says John Veal, the TVA project manager. "The project team, made up of State employees, engineering firms, and TVA personnel, worked together to refine the scope and match it to the needs of the State. The team was critical in making the project a success, and it operated with an unusual amount of autonomy." In the course of the project, the team found ways to improve the ability to account for, monitor, and manage energy consumption beyond those outlined in the original design.

One unique aspect of the approach was the full-time, onsite energy manager who coordinated State and TVA resources, served as a communication link between State personnel and TVA, provided direct technical support for operations and maintenance, and identified additional energy savings. He was able to operate with

Energy Conservation Measures Summary

Description	Energy savings	Estimated costs	Simple payback, years
Lighting	$99,904	$447,851	4.5
Lighting Controls	$74,858	$286,459	3.8
Energy Management System	$448,305	$1,208,320	2.7
HVAC Upgrades	$76,860	$986,291	12.8
Motors & Drives	$113,786	$311,729	2.7
Sprinkler System	-	$434,520	-
AJ Ceiling	-	$317,764	-
Total	**$813,713**	**$3,992,935**	**4.9**

a high level of independence, and his only interest was the success of the project.

"This proved to be one of the best decisions made in the course of the effort," says Dave Edmunds, Director of State Building Energy Management. "The resolution of problems and issues, especially operational ones, was exceptional. Many potential problems were identified even before they became a reality."

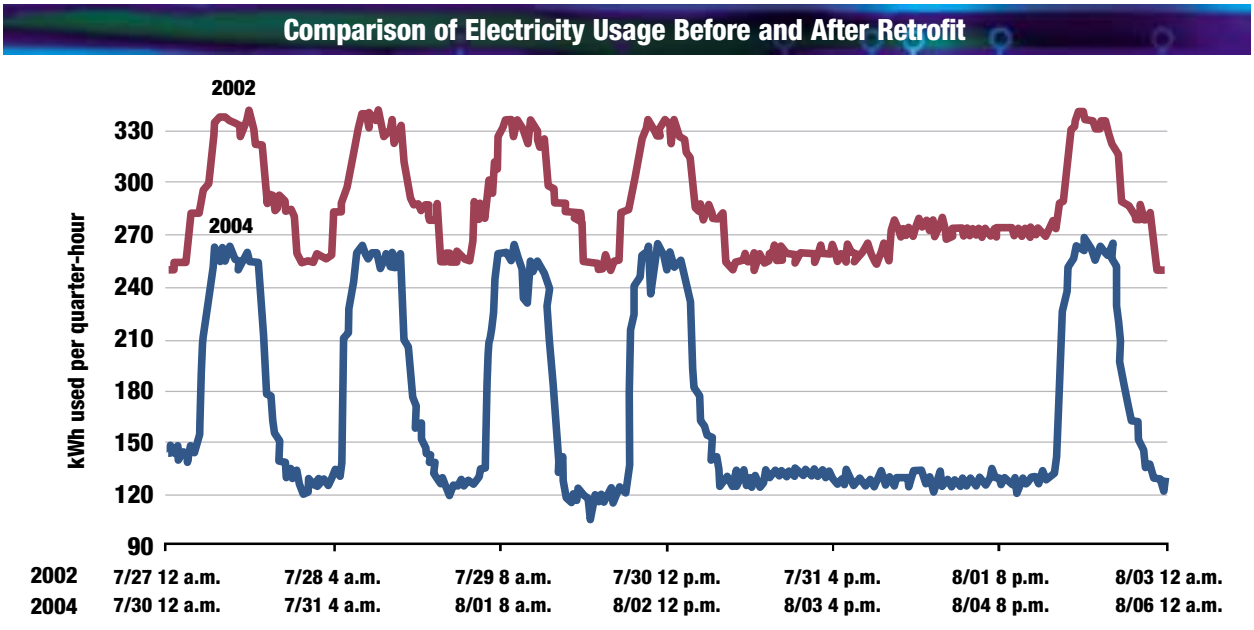
The private companies involved in the project included Allen and Hoshall for engineering and design work, Siemens for mechanical work, Light Incorporated for lighting, Comfort Group for the energy management system, and AEC for monitoring and verification.

Results and impacts

The project was begun in November 2002 and was substantially completed in September 2004. Most of the work was done at night and on weekends to minimize the disruption to the State agencies housed there. The results have been impressive:

- A 55 percent reduction in energy consumption for the buildings
- A 42 percent measured reduction in electricity consumption: 14 percent from the lighting retrofit alone, and the balance from lighting control, installation of variable frequency drives, and environmental control management
- Lowered costs for chilled water and steam
- Tighter control of the building environment with greatly improved air quality and consistency of temperature and humidity
- No fluctuations in interior temperatures with the weather
- Lighting with a better, more natural quality.

As the chart below shows, the drop in electricity usage is dramatic and consistent. Data from the Nashville Electric Service record an average reduction of more than 13,000 kilowatt-hours per day from July 2002 to July 2004.



The chart shows electricity usage in the buildings for a one-week period in July - August 2002, before the retrofit, and a comparable period in 2004, after partial completion. (Data from NES.)

Bill Griffith, the DGS Facility Administrator, reports great satisfaction with the increased control of heating and cooling. "The system gives instant feedback, so that if something goes wrong with the heating at 3 a.m. on a cold winter morning," he says, "the problem can be addressed and employees will still show up to a warm building at 8." In addition, employees working after-hours and on weekends have local control of air temperature and lighting so that electricity usage doesn't have to be kept up in the entire building to accommodate just a few workers.

The even temperature and natural quality of lighting provided by the building upgrades create a much more comfortable environment for occupants than was possible with the original inefficient energy systems.

Energy conservation measures

The results outlined above were achieved through the implementation of the following energy conservation measures, as proposed in the detailed energy study:

Lighting retrofit

The lighting upgrades were addressed first in order to realize some energy savings as soon as possible. The work was completed in three months and produced immediate results.

- Existing F-40 fluorescent lamps, magnetic ballasts, and incandescent lamps were replaced with energy-efficient ones. The new fluorescent lamps are 32-watt T-8 models, and the ballasts are low-energy electronic ones.
- Incandescent lamps were replaced with compact fluorescent lamps that provide higher levels of light output per watt.
- All exit lights were retrofitted with LED lights.

Throughout the Andrew Jackson and Rachel Jackson buildings, existing fluorescent lamps and magnetic ballasts, as well as incandescent lamps, were replaced with energy-efficient models.

Overall energy consumption is reduced thanks to local control panels for lighting and heating or air conditioning.

Lighting controls

- Controls for the office space were installed to limit the use of lighting when the buildings are unoccupied.

- Local control panels on each floor enable tenants to request lighting and HVAC service outside of normal work hours with the push of a button.

HVAC upgrades

Multiple energy conservation measures were designed to eliminate simultaneous heating and cooling and achieve better overall comfort and control for the buildings.

- The chilled water system supporting the core air-handling units was converted to variable volume. A control valve was added at each unit, converting from constant volume to a more efficient demand-managed flow volume.

- The constant-speed chilled water and hot water distribution loops were converted to variable-speed pumping.

Air circulation in the buildings was improved by converting the air handler from 100 percent outside air to return air. The control of air temperature, humidity, and carbon dioxide levels means a much higher level of air quality throughout the structures.

The project team not only supervised the installation of new energy systems but also worked with the building staff to refine their understanding of the upgraded equipment.

- Other HVAC upgrades included repairing piping crossovers, drainage leaks, mechanical louvers, roll filters, and other items to ensure proper operation of the existing system.

- Improved air distribution and conditioning was installed in the first floor lobby of the Andrew Jackson building, and thermal barriers were added to selected windows in the Rachel Jackson building.

- Quick-acting doors were installed at service entry points at the garage level to effectively separate conditioned and unconditioned spaces, thus preventing winter heat loss.

Energy management system

An energy management system was installed to provide HVAC control.

- The system is a BACNet™ local area network providing direct digital control of management and automation.

- A centralized control station is located in the maintenance area of the buildings.

Direct digital controls enable the facilities staff to regulate, manage, and monitor the building systems while optimizing their performance.

Decisions about whether to upgrade existing equipment or install new components were made throughout the project on the basis of the performance level to be achieved.

- The system uses intelligent distributed control modules with applications such as night setback, demand limiting, and optimum start and stop.

Motors and drives

- Variable-frequency drives were installed on pumps and certain air-handling units.

The exceptional cost payback resulting from the project provided the opportunity to address items that would otherwise have been omitted, such as work on the fire protection system and ceiling replacement. These enhancements have also contributed to the safety and comfort of the buildings' occupants.

Conclusion

The project has had a much greater impact than anyone expected, according to the State's Dave Edmunds. "In addition to far exceeding the original predicted savings, a significant opportunity for improved operations, maintenance, and communications support was identified and captured by the project team," he says. "The continuation of these efforts ensures that the improved performance of the two buildings will continue long into the future."

The State of Tennessee has 72 million square feet of facilities, including many older buildings with outdated environmental-control systems. With the successful completion of the AJRJ retrofit, the State can undertake similar projects confident that the energy savings performance contract offers a workable model with predictable results and that the projects will actually pay for themselves through reduced energy usage. "We in General Services are very proud of the accomplishments in Andrew Jackson and Rachel Jackson," says DGS Commissioner Gwendolyn S. Davis, "and we fully support our other ongoing energy-savings activities."

The project's successful completion proved to be a home run for all three of the public agencies involved. "There were no negatives here," says Jim Purcell, energy services manager for Nashville Electric Service. "In terms of energy savings to the State, customer goodwill, and our longstanding partnership efforts with TVA to provide maximum value to consumers, it was a project that benefited everyone."

For more information, please see the State Building Energy Management Program site at www.state.tn.us/finance/cpm/energy.html.

Variable speed drives integrated and controlled by the energy management system deliver volume to meet demand, improving system control and reducing energy consumption.