

The Role of Existing Building Commissioning in the State of Tennessee's Energy Management Program

*Dave Edmunds, State of Tennessee, Nashville, TN
Tudi Haasl, PEI, Portland, OR*

ABSTRACT

The State of Tennessee recognizes that significant amounts of energy may be wasted in existing state buildings due to inefficient operation and maintenance of heating, cooling, and ventilating equipment and unnecessary operation of lighting systems. In 1994, the State of Tennessee began to explore the benefits of building commissioning to better understand how existing-system commissioning might improve state building performance. This effort resulted in an initiative that seeks to educate and obtain a commitment from key administrative state government officials, explore the barriers to efficient buildings in Tennessee, and develop guidelines for implementing building commissioning programs and activities for the state. The Department of General Services' State Building Energy Management Program is primarily responsible for this effort. Although they have experienced both successes and set backs in making commissioning "business as usual" for the state, they remain convinced that commissioning activities are the catalyst for overcoming the barriers to efficiently operating and maintaining their buildings.

This paper describes the evolution of existing-systems commissioning for the state of Tennessee. Findings from the commissioning demonstration project are reported including costs, energy savings, and non-energy benefits. How commissioning, performance contracting, and utility partnering in an atmosphere of deregulation might work together to provide the state of Tennessee with energy-efficient and comfortable buildings is discussed.

Introduction

In 1994, the State of Tennessee in its efforts to explore the benefits of building commissioning attended the second National Conference on Building Commissioning and began an initiative. The initiative sought to educate and obtain a commitment from key administrative state government officials, explore the barriers to efficient buildings in Tennessee, and develop guidelines for implementing building commissioning programs and activities for the state. The State Building Energy Management Program was primarily responsible for that effort. Although there have been both successes and set backs in making commissioning "business as usual" for the state, program management remains convinced that commissioning activities are the catalyst for overcoming the barriers to efficiently operating and maintaining their buildings. This paper presents the findings from the commissioning demonstration project using the Chattanooga State Office Building along with a description of the state's commissioning program development, and its integration into the state-wide strategic action plan.

Commissioning the Chattanooga State Office Building

The initial scope of the project was to commission the existing building systems. However, the project ultimately included commissioning a new Johnson Control Metasys energy management control system (EMCS). The expanded scope allowed the project to demonstrate the commissioning outcomes for both a new installation as well as for existing building systems. Although some of the improvements implemented using the new Metasys could have been accomplished with the existing EMCS, it lacked several points of control necessary to support more sophisticated control strategies. This coupled with the fact that the specified training was never provided to the building staff and the vendor was continually unresponsive to the staff's requests for assistance, caused the replacement.

Commissioning of a new installation cannot guarantee a vendor will be responsive once the job is finished, however, had the existing system been commissioned when it was installed, it would have ensured that the system initially operated and met design intent. It would have also ensured that the building personnel were trained as specified.

This project is unique in that it involves the State of Tennessee, the Tennessee Valley Authority (TVA) and the Electric Power Research Institute (EPRI). Each have different but related commissioning goals and objectives. The section "Commissioning Objectives" summarizes the various parties interests and goals for the project.

Commissioning Objectives

One of the primary reasons for choosing the Chattanooga State Office Building for the commissioning demonstration project is that the Tennessee Valley Authority (TVA) and the Electric Power Research Institute (EPRI) also have related projects planned over the same time period using this building. Sharing and combining of resources to reduce costs and obtain as much data as possible appeared reasonable. The following explains each party's project objectives.

State of Tennessee Commissioning Objectives

The State of Tennessee, Division of General Services, project objectives are to:

- Obtain cost effective energy savings from commissioning building systems. Tracking these savings requires monitoring selected building systems.
- Identify and recommend operations and maintenance procedural improvements focusing on those measures that will sustain optimal energy performance and reduce operating costs.
- Identify HVAC-related health and safety issues as they present themselves during the normal course of the commissioning work.
- Obtain background information for the development of a state-wide program design for commissioning all existing state buildings.

TVA and EPRI Commissioning Objectives

TVA and the EPRI Commercial Building Performance Evaluation Tailored Collaboration selected the Chattanooga State Office Building to perform further demonstration of the Commercial Building Performance Evaluation System (CBPES) and to further develop one of the CBPES

application modules, HVAC Evaluation System (HES). The goal of the collaborative as it relates to the State Office Building project is to develop and test the HVAC Evaluation System (HES), using the State Office Building as the test site. CBPES is a combination hardware and software package designed for analyzing building energy performance. Once completed, CBPES can be applied in the building commissioning process.

Commissioning Approach

Through a commissioning assessment process, investigators observed the building's present operation and maintenance strategies and practices in an attempt to find cost-effective improvements. The project did not include extensively identifying or implementing energy-efficient capital improvements. However, in the course of the commissioning process, any energy-efficient capital improvement that was thought to be effective, was offered as a recommendation for further investigation.

Commissioning included the following steps:

- Developing a building-specific commissioning plan
- Performing an on-site survey of the present maintenance practices and operating strategies
- Developing commissioning specifications for the new EMCS
- Performing short-term diagnostic monitoring of specific systems including the new EMCS
- Developing a "master list" of deficiencies and low-cost O&M improvement for both the new EMCS and existing systems
- Overseeing the new installation is installed as specified and all deficiencies found during commissioning are adequately addressed
- Developing recommendations for the most cost-effective improvements
- Implementing the improvements
- Performing post-improvement monitoring as needed
- Calculating the energy savings obtained
- Submitting a final report

During the monitoring period, portable dataloggers measured current, temperatures, pressures, and humidity for areas, systems, and equipment thought to exhibit the most opportunity for improvement. Once the monitoring data was analyzed along with the on-site assessment findings, a "master list" of recommended improvements was submitted to the owner's representative, facility manager, and other commissioning team members. Together they decided which improvements appeared to be most cost-effective to implement within the project's time frame. After implementing the improvements, another two weeks of monitoring data was gathered and analyzed to ascertain the effectiveness of the improvement regarding energy, demand, and comfort conditions.

Ultimately the cooling and heating savings were calculated using the ASHRAE modified bin method. Bin temperatures were also used to determine fan and pump energy savings. The short-term diagnostic monitoring data was used to inform the calculations. (For more discussion on using short-term diagnostics refer to the paper "Uncovering Hidden O&M Problems with Short-Term Diagnostic Testing" by Mark Arney et al. presented at the 1995 National Conference on Building Commissioning.)

Building Description

The Chattanooga State Office Building, located in Chattanooga, Tennessee is a seven story, 175,000 square foot office building with an underground basement. The east wing of the building was constructed in 1950 and the west wing was constructed in 1970. The building uses natural gas for heating and electricity for cooling. New chillers along with a DDC energy management control system (EMCS) were installed in 1994. However, the EMCS was replaced with a new system during 1996-97 commissioning study.

The mechanical system is a built-up (two pipe) system composed of 19 air handling units and approximately 418 under-window unit ventilators. The primary plant equipment is comprised of two steam boilers, a hot water heat exchanger, two 300 ton chillers and one open loop cooling tower. The main control for the HVAC equipment is accomplished with a DDC energy management control system.

Lighting control is accomplished by manual switches. The lighting for the office areas consists primarily of standard ceiling mounted fixtures containing two to four 34-Watt fluorescent lamps with incandescent lighting in the entry lobby.

For the most part, preventive maintenance tasks for HVAC are performed by the in-house staff. Service contracts exist for annual and semi-annual maintenance on the boiler and chiller plant equipment.

Summary of Commissioning Findings for the Chattanooga State Office Building

The commissioning investigation identified 45 possible improvements. The opportunities fell into the following categories:

- Heating ventilating and air conditioning (HVAC) for both plant and distribution systems
- Controls (DDC)
- Miscellaneous (such as documentation, O&M planning, domestic hot water, etc.)

Of the possible 45 improvements 55% have been implemented to date. All of the opportunities leading to significant energy savings have been implemented. Table 1 shows the energy related improvements and the potential savings opportunities. Most of these were accomplished by including equipment schedules and control strategies in the new EMCS along with commissioning for both the new system and the existing controlled equipment.

Although the improvements listed in Table 1 appear to be fairly simple, what is not apparent are the related improvements to the controlled equipment or the commissioning issues with the new system. For example, not only is the economizer control strategy improved through the EMCS but many related dampers and actuators were commissioned and repaired. The new-system commissioning also included checkout of sensor calibration and the proportional interface between the EMCS and the damper actuators. Without this integrated approach, incorporating the improved operating strategy would have failed to deliver any value on its own.

Table 1: Potential Annual Energy Savings from Selected Improvement for the Chattanooga State Office Building

Improvement Description	*Issue	Savings (\$/yr.)
Add scheduling (automated) - plant equipment	O/I	27,494
Add scheduling (automated) - air handlers	O/I	24,145
Improve economizer operation for eight air handlers	O/I	742
Incorporate chilled water reset	O	1,285
Reduce chiller lockout setpoint to 60° F	O	579
Reduce freeze protection setpoint to 35° F	M	5,968
Total Savings		60,213

* The "Issues" column categorizes the improvement as primarily either an operation (O) or maintenance (M) issue. The I following the backslash (/) indicates the source of the problem was from initial installation (I) f the old EMCS.

For some of the improvements listed in Table 1, a range of savings is possible depending on which condition was used in determining the savings. In these cases, the mid-range value (the average of the high and the low savings estimates) is reported. For example, economizer operation had a low range savings of \$495 per year and a best case of \$989 per year. Table 1 reflects the mid-range value of \$742 per year. In the final analysis for Tennessee, the interactive effects among the improvements will also be considered. This may reduce the saving figure reported here. However, to date, not all of the implemented improvements and their respective saving calculations are complete. Considering the interactive effects and some additional improvements, a savings range of between \$60,000 and \$63,000 is a reasonable expectation. From recent conversations with the buildings Facility Manger, the expected saving are being realized to his satisfaction.

Project Costs

The total cost for the project, including the installation of the new EMCS and the commissioning of both the existing building systems and the new EMCS totals approximately \$110,000. Using the savings figure of \$60,000, this results in a simple payback of 22 months or less than two years. If most of the improvements implemented as part of the new EMCS had been implemented using the existing EMCS (assuming it had the appropriate capabilities), the pay back for just the commissioning would have been less than one year.

Another way to look at cost is to consider the commissioning cost per square foot. With a commissioning budget of \$50,000 and a square footage of 175,000, the commissioning cost equals 28.5 cents per square foot. At first glance this appears high. However when the project is put in perspective, i.e. a project that includes both the commissioning of a new system and the existing systems with all the extraneous costs attributable to a "demonstration project", the per square foot cost looks more reasonable. As the state of Tennessee pursues other project and becomes more self-sufficient at obtaining commissioning services, the costs should go down considerably.

State of Tennessee's Commissioning Program Development

Tennessee Building Commissioning Initiative

The State of Tennessee in its efforts to explore the benefits of building commissioning began an initiative in 1994, with assistance from Portland Energy Conservation, Inc. (PECI), to educate and obtain a commitment from key administrative state government officials, explore the barriers to efficient buildings in Tennessee and develop guidelines for implementation of building commissioning (Cx) programs and activities for the state. The major components of this initiative are:

- Tennessee Building Commissioning Workshop
- Building Tune-Up Demonstration Project
- Demonstration Commissioning Project
- Tennessee Building Commissioning Guidelines
- Integration of Commissioning into the State-Wide Action Plan

Tennessee originally planned to take a phased approach to learning about commissioning as a potential method for assuring quality buildings, operational efficiency and establishing guidelines for implementation of commissioning practices. Phase One - a workshop for government officials and private sector representatives - was successfully conducted in December of 1994. With a changing administration and a new management philosophy came a revised plan. Under this new plan, Phase Two became a full-scale commissioning effort at the Chattanooga State Office Building. There were two primary objectives: a fully commissioned building and draft guidelines for implementation in our remaining buildings.

The state was fortunate to have another of its buildings selected as part of a national operation and maintenance (O&M) demonstration project in 1995. Citizens Plaza, an office building in Nashville, was one of five buildings in the United States selected to participate. The study was conducted by PECO and funded by the Atmospheric Pollution Prevention Division of the U.S. Environmental Protection Agency in cooperation with the U.S. Department of Energy (Haas et al. 1996). The study demonstrated that energy savings opportunities exist in office buildings and can be realized by implementing inexpensive improvements in O&M procedures and equipment. Based on the success of the commissioning workshop, the national O&M demonstration study, the state's demonstration project, and the successful adoption of implementation guidelines, a state-wide action plan is being developed that includes commissioning for both existing and new systems.

Tennessee Integrated Energy Services Process (TIES) Proposal

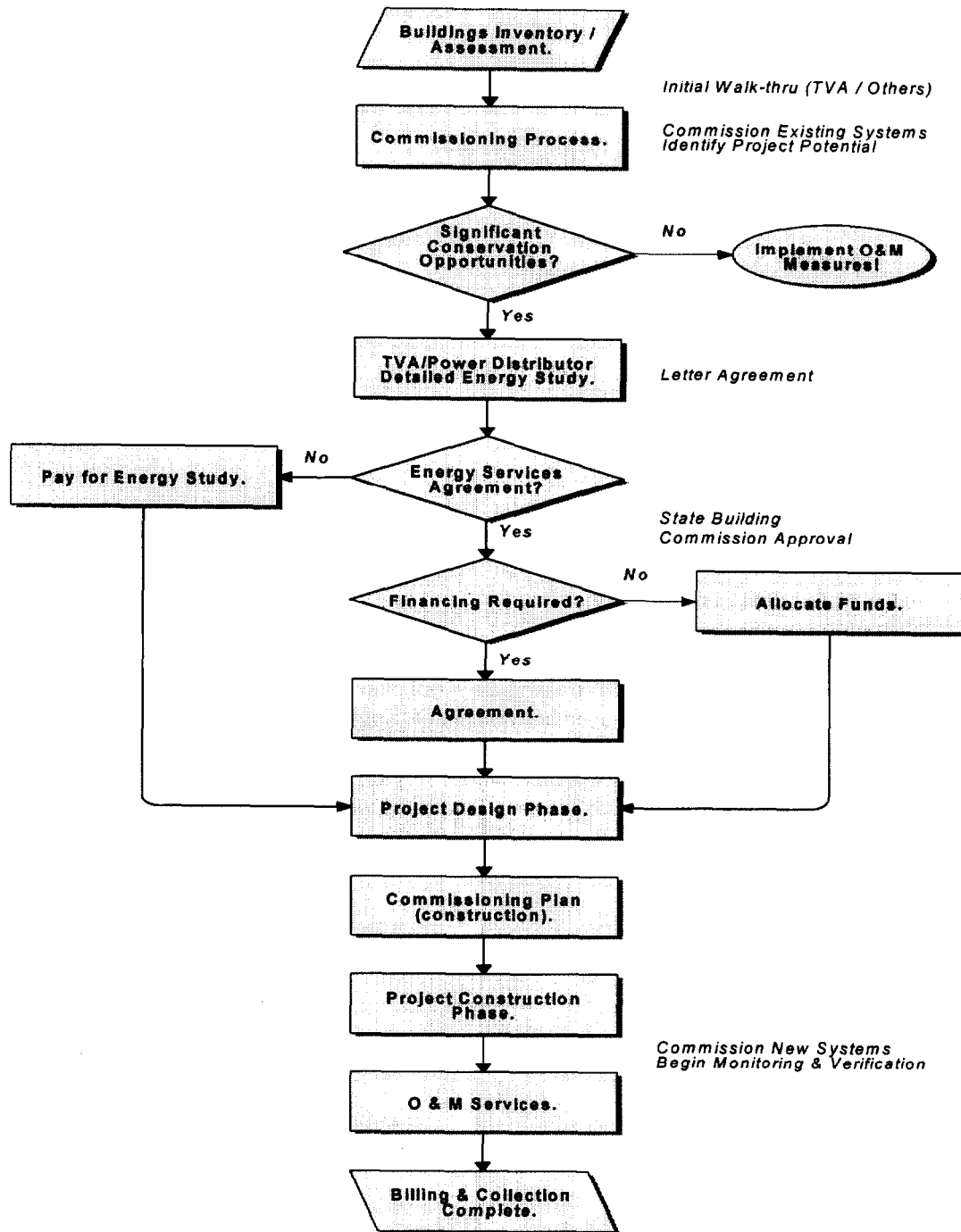
The State Building Energy Management Program (SBEM) intends for building commissioning to be the foundation from which integrated, multi-disciplined energy programs and services should be provided. Combined with performance contracting, this is perhaps the only approach that can integrate the various program objectives, maintain a long-term perspective, reduce overall owning and operating costs, and insure program success.

SBEM is currently working with State officials, U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), TVA, local power distributors, and energy and commissioning consultants to develop and implement a strategic action plan for providing O&M,

commissioning, and related energy efficiency services with a minimum impact on current operating and maintenance budgets. Based on the success of the two demonstrations projects at Citizen's Plaza and the Chattanooga State Office Building, and based on an on-going investigation of performance contracting, SBEM is convinced that the best approach for Tennessee should include the following elements:

- I. **Appropriate commissioning efforts** at all existing state owned buildings (including repairs & fixes):
 - A. Testing and monitoring
 - B. O&M tune-up and repairs
 - C. Monitoring and verification, establishing performance baselines
 - D. Identifying energy efficiency opportunities (capital improvements)
- II. **Partnerships with the Federal Government, Utilities, Local Power Distributors** as well as contractors and consultants providing the following services:
 - A. Program development
 - B. Engineering and consulting services
 - C. Advanced metering services
 - D. Building commissioning services for both new and existing systems
 - E. Pilot performance contracts
- III. **Performance Based Contracts** for services when significant energy savings can be identified.
 - A. Detailed energy studies
 - B. Energy services agreement
 - C. Project design and construction
 - D. Commissioning of new systems (retrofits)
 - E. Operation and maintenance services for buildings receiving retrofits
 - F. Monitoring and verification

The following diagram shows how this process might work:



Proposed Tennessee Integrated Energy Services Process

An Overview of the Proposed Action Plan

The State of Tennessee spent approximately \$72 million for energy to operate state-owned buildings in 1988. In 1998, that annual bill grew to between \$80 and \$90 million. Projected out to the next ten years, at a 2% growth rate, the bill approaches \$120 million. The proposed action plan's vision, priorities, goals and organization if successfully implemented, will establish an effective, self-funded program to reduce the growth of energy costs and reduce deferred maintenance in State buildings. Specifically, it addresses how the State Building Energy Management Program (SBEM) can provide leadership in a state-wide strategic plan that will improve the operation, maintenance, energy efficiency and working environment in all state-owned buildings while reducing energy costs.

Plan Objectives:

- **Reduce energy consumption** and costs in State buildings (through improved energy efficiency)
- **Reduce or eliminate current deferred maintenance** in State buildings
- **Incorporate energy efficiency in the planning and design** of new facilities

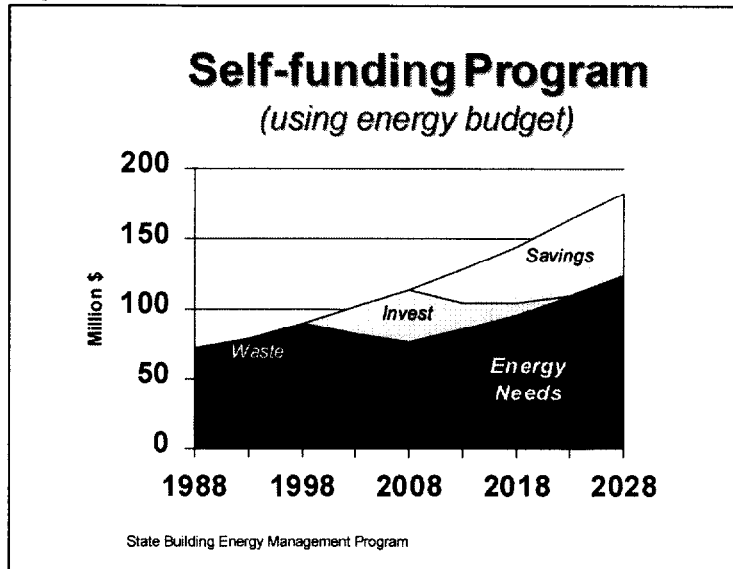
Vision and Mission

The vision is that all State buildings provide a safe, comfortable and productive work environment while operating at optimum energy efficiency. The mission is to introduce, initiate and implement programs that will improve safety, comfort and energy efficiency at all State buildings.

Plan Concept

This plan is designed to be self-funded by using the savings generated from facility modifications to provide the investment capital required to fund the modifications. Under this concept, the energy budget is "fixed" for a life cycle of twenty years. During the first ten years, savings are used to pay down the capitalized costs and during the last ten years, there are "net" savings to the State (Figure 1).

Figure 1



This plan is modeled after and developed in partnership with the U. S. Department of Energy's (DOE) Rebuild America Program. In this plan, State agencies voluntarily become partners in the SBEM program through a letter of commitment. Partner agencies will receive technical support, implementation standards, coordination of program resources, and follow-up monitoring and verification of savings from SBEM. A pilot agency will be selected to test the implementation process and gauge the resource requirements for a more aggressive implementation of the plan statewide.

Attainable Goals Over the Next Five Years

- Obtain 30% savings in annual energy and maintenance costs at buildings brought into the plan (20% from energy efficiency measures and 10% from improved O&M through commissioning existing building systems).
- Implement all appropriate energy efficiency measures at facilities included in the plan (this is possible since new capital is not required).
- Survey and retrofit 20,000,000 square feet of state-owned space (resulting in \$8,800,000 in annual energy savings and pollution reductions equivalent to 4,000 fewer cars).

Conclusions

By implementing the proposed action plan the State will benefit from more efficient buildings, increased productivity of employees due to improved living and working environments, reductions in the number of employees / contracts (and thus expenses) for operation and maintenance from improved maintenance conditions. In addition, this can be accomplished with little or no internal capital funds. By integrating the systematic approach that commissioning offers to identify low cost improvements for existing systems and ensure quality for new installations, the State hopes to realize the following direct and broader benefits.

Direct Benefits:

- Reducing energy consumption will reduce energy costs and environmental pollution
- Leveraging current program resources will produce “more bang for the buck”
- Improving the monitoring and follow-up of efficiency upgrade projects will ensure success
- Improving the operation and maintenance through commissioning of existing state buildings will reduce the number of emergency repairs and reduce operating costs
- Increasing the environmental awareness of facility managers, tenants and clients will result in a cleaner environment
- Improving the physical plant will result in fewer “trouble” calls from unhappy tenants

Broader Benefits:

- Spur economic development in urban areas
- Fuel economic growth by converting energy savings into local jobs and community investments
- Reduce pollution and demand on existing power plants
- Be better prepared for de-regulation of electric utilities

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