

Commissioning Energy Performance Contracts

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Synopsis

This paper will describe the challenges associated with applying sound commissioning techniques within the procurement and implementation process of an Energy Savings Performance Contract (ESPC). The paper will review the structure of an ESPC and define the areas where commissioning is needed. It will focus on lessons learned from commissioning a specific ESPC project to install high efficiency lighting, energy efficient HVAC systems, and an Energy Management System (EMS) in several higher education facilities. The paper will also describe the contractual arrangements used under that specific contract.

About the Authors

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Introduction

An Energy Savings Performance Contract (ESPC) is a popular method for owners to implement building infrastructure system upgrades upon procurement. In most cases, these projects will include an upgrade of major heating, ventilating, and air conditioning (HVAC) systems such as chiller and boiler plants and air-handling systems, and installation or upgrade of a building automation system. These projects require comprehensive planning, adherence to high construction standards, and regimented quality control procedures.

Typically, these projects evolve from concepts developed in an energy audit, and often the owner offers little input into the development of the detailed design. The project usually proceeds to the implementation phase without formal specifications, and without clearly and thoroughly identifying owner's requirements, which are often addressed generically and not in sufficient detail in the general terms and conditions of the contract documents. This poses unique challenges when planning and implementing the commissioning process to the project. We believe that there is a strong business case for both ESPC provider and owner to incorporate commissioning at an early stage of the planning as this minimizes causes for conflict during the later stages of the project.

Energy Savings Performance Contracts

Energy Savings Performance Contracts have been in existence for over 20 years. They are long-term contractual (10 years and longer) instruments used by municipal agencies, universities, schools, hospitals, and federal agencies to procure energy efficiency projects. These contracts use energy and operational cost savings to pay for the initial investment and provide the owner saving guarantees; thereby reducing associated performance risks. A database of ESPCs developed for the National Association of Energy Services Companies (NAESCO) now contains over 2100 contracts. Market size since those 20+ years was estimated by the database to be over \$16 Billion for the municipal, university, hospital, and schools alone. The federal market was estimated to be at \$1.6 Billion over 10-15 years.¹

Procurement

The process used by owners to procure an ESPC is fairly uniform across all markets. It usually starts at the institution level whereby a facility manager or engineer identifies one or more problem or need related to the facility's energy using systems; with or without the help of an energy services provider. That need is usually incorporated into a preliminary energy audit report and then presented to decision makers, such as a School Board, for review and approval. With the help of an energy consultant, the institution then prepares a request for proposal (RFP). The consultant can be a private firm, a state agency, or an Energy Services Company (ESCO). The RFP response will involve an Investment Grade Audit, which includes a description of energy conservation measures, analyses of energy and operational cost savings, estimates of the

¹ Hopper, N., C. Goldman, D Birr, et al. 2004 *The Federal Market for ESCO Services: How Does it Measure Up?* Downloadable at http://eetd.lbl.gov/ea/EMS/EMS_pubs.html

cost to implement such measures, and establishment of saving guarantees by the provider as a result of implementing such measures. RFP respondents put together a conceptual design, the details of which are limited by the level of effort and resources judged to be appropriate to the chances of being awarded the contract. A third party Professional Engineer typically evaluates the responses to the RFP. The evaluator will examine the technical soundness of the scope, the cost parameters, and the depth of experience of the bidders. Great weight is given to an ESCO offering the largest scope of work within a given budget level.

As a result of the evaluation process, a recommendation is then made to the owner representative and, in turn, to the governing board. Contract negotiations will then begin and scope revisions, value engineering, and cost modifications will ensue. Savings guarantees over the term of the contract are established. The methods to measure and verify (M & V) those savings are incorporated into the Contract. Also, the remedies for any failure to achieve these guarantees are defined.

Execution

Work scope is often implemented using a fast track design/build process. The ESCO prepares a scope document and may bid or negotiate purchasing and installing the proposed systems. In most cases, the ESCO and their subcontractors would have already negotiated sub-contract scope and price during the RFP phase. The ESCO's focus is to execute all trade subcontracts within the pricing structure agreed upon earlier and to shift some of the risk to the sub-contractor. As the work progresses, the ESCO's focus tends to shift toward ensuring that the project is progressing on budget as well as toward completing distinct portions of the work (termed Substantial Completion) on schedule in order to begin taking credit for any savings associated with the completed portions (these are termed construction period savings). These savings credits are allowed to offset any savings deficit when the project is totally complete.

The owner may or may not have an in-house project manager qualified to oversee such projects. For example, federal agencies tend to have such expertise, but school districts and some universities may not have the in-house resources necessary. In most cases, a Facilities Director or his/her representative performs owner oversight. With that in mind, the ESCO is heavily relied upon to provide the role of project and construction management to implement project controls.

Measurements and Verification

Most ESPC projects use the International Performance Measurement & Verification Protocol (IPMVP) to perform measurement and verification of the guaranteed savings. Savings from almost all implemented energy efficiency measures are often stipulated. Only a few parameters are actually measured. Measuring energy consumption before and after an equipment replacement project is completed, easily validates savings realized from replacement of inefficient equipment with energy efficient equipment. Many of the criteria used to estimate savings, such as run times, are established during the procurement process. These measurements and savings calculations take place during a reconciliation process usually within 60 days of the

Substantial Completion date. Savings achieved during the Installation Period are calculated and used as credit against any future shortfall.

The Case for Commissioning

The process of commissioning needs to be included at the early stage of project design and development, given the detailed nature of procuring and executing an ESPC. Significant shortcomings seem to exist at the project scope development phase of the ESPC process. A lack of sufficient effort, expended during the early project phase, causes critical details to be overlooked, thereby adversely impacting project cost and/or functionality. As a result, disputes and/or claims over scope responsibility between owner, ESCO, and subcontractor will likely occur. In addition, saving guarantees may be jeopardized. Commencing commissioning at the early stages of the ESPC project will ensure clarification of owner's requirements. We also believe that there are several other areas of prominence in the process where commissioning is essential, such as: functional testing, training, and operation and maintenance documentation.

Commissioning during scope development

Scope development is the most critical phase of an energy efficiency project, yet the structure of an ESPC does not afford the necessary resources and efforts to clearly and accurately identify such scope. The result is a scope of work that may or may not be sufficient to address the existing conditions and to provide a sound basis for the proposed energy efficient strategy.

To illustrate this point, we offer the following example: As part of an ESPC, a recommendation was made to abandon operating a heat recovery chiller in a facility in winter and instead to use an airside economizer to obtain free cooling and to use the existing steam-to-hot water heat exchanger to provide heating. An energy simulation model proved that savings would be large enough to justify the cost of the measure. After the contract award and execution of the work, it was discovered that the proposed strategy would not function as planned because the existing damper linkages were disconnected, the dampers would go out of adjustment very quickly, the controls needed calibration, and some of the hardware was rusted in position. In addition, malfunctioning freeze stats made it impossible to operate the outside air intake dampers properly, in some cases. To correct the existing deficiencies, a separate contract had to be issued, the cost of which could have been reduced if these deficiencies were identified and planned for at the onset of project plan development. Consequently, the project return on investment was reduced substantially.

In general terms, several aspects of an ESPC provide the reasons why commissioning is necessary during scope development:

- The conceptual design, used during the proposal phase to establish a budget becomes the project design to be executed by the contractors.

- The ESCO is bound only to provide the scope described in the RFP in general terms. For example: replace chillers, boilers, pumps, towers, air-handling units and controls, while meeting the financial terms of the agreement.
- Typically conceptual designs for budgeting do not address the details necessary for “operator friendly” (easily accessed, operated and maintained) systems.
- Pressure and Temperature indicators, valve position indicators, lighting, access ladders, labeling, maintenance clearances, availability of ancillary equipment such as hose drops and electrical outlets, proper abandonment of existing equipment, and so on, are the types of issues easily overlooked by the Mechanical/Electrical/Plumbing (MEP) contractor when putting together a quick proposal price without owner issued specifications.
- Equally easily overlooked is the difference between the conceptual Building Automation System (BAS) functionality and the level of sophistication desired by the operating engineers who in almost all cases were not involved in the scope development.

Traditional Commissioning Needs

In addition to recommending that commissioning be included during scope development, we suggest that traditional commissioning adds significant value to an ESPC. Just as in a major energy efficiency project, in a commissioning project it is important to ensure functionality, to train the building personnel, and to provide personnel with sufficient instructions to operate the new systems properly.

Functional Testing

ESPC scopes tend to include major HVAC system improvements including high efficiency equipment and building automation systems. The majority of these ESPCs are provided by ESCO’s that are affiliated with temperature control providers. There is a tendency to include start-up features that resemble functional testing as defined in traditional commissioning. However, the ESCO’s objectives are usually to ensure that the energy efficiency measures, related to their guaranteed savings, are in place and not necessarily to ensure that any other features that contribute to overall system functionality or performance are included. For example, an installed system might be tested to ensure that it turns off during unoccupied hours but may not be tested to ensure that during occupied mode, all functional and efficiency features are functioning as desired.

Typically, the ESCO will take a “snapshot” of the energy consumption during a stabilized condition such as in heating mode, cooling mode or economizer mode. While this data is important, it only provides a partial energy usage picture. By performing trend analyses of critical components during the transitions between operating modes, any logic weaknesses in the sequence of operations (or in the programming that implements that logic) will be revealed. Finding conditions such as heating while economizing, heating while cooling, transitioning straight from morning warm-up to cooling at occupancy, and other such energy wasters are not unusual. Functional testing of this rigor is not typically performed by the ESCO.

Training

Training requirements are rarely included in the contract documents, other than as a general requirement. Typically, the number of hours is not specified and, therefore, the amount budgeted by each contractor differs substantially in both quantity and quality from the operators' expectations.

Operation and Maintenance Manuals

With no guidance or obligation from a specification, the contractors budget for and deliver the vendor manuals that they receive upon equipment delivery "as is". Sometimes only the "cut sheets" used to price the job are delivered. These manuals are little more than vendor catalogues. The owner is left to figure out which model(s) are installed and what options were provided.

Case Study: Commissioning ESPC at a Higher Education Institution

The authors were hired by an ESCO to provide third party commissioning services for an ESPC at several facilities of an institution of higher education. The owner had requested commissioning services in the RFP. The commissioning section in the RFP consisted of one paragraph that required the respondent to have a commissioning process in place to assure that the systems operate as designed and intended. Although the language used by the RFP was general, it provided a good opportunity to attempt to apply the steps defined by the commissioning community and available through resources such as Portland Energy Conservation Inc. (PECI) to the project.

We were invited by the ESCO to provide commissioning services and became a part of the project team, which included the Owner's facility director, the ESCO (who is also the temperature control provider), a joint venture that included the MEP engineering firm and the mechanical contractor, and an electrical/lighting contractor.

The timing of our involvement as commissioning agents and the fact that we were hired by the ESCO provided many challenges and learning opportunities. However, the measurable benefits from the involvement of a commissioning agent were evident to both the ESCO and the owner.

Commissioning Contributions

The ESCO and the MEP in this case were builders and contractors. Their expertise is in construction and contract management and this influences their perspective and focus. Being independent and outside that sphere of business drivers, we were able to provide an alternative perspective, one of the owner/user/operator, to the decision making process at project meetings. Many times, changes that were beneficial to the owner were readily agreed to so long as the budget was not impacted. When these changes could not be provided within the budget, they were presented to the owner who would then decide whether or not to issue a change order. But the alternatives would never have been considered without someone in the role of a

Commissioning Authority. The structured approach to pre-functional and functional tests had a trickle-down effect that directed the trades to adhere to schedules and to include the details necessary for such tests.

The following examples highlight the issues discovered before installation:

- The mixed air plenum pressure sensors were going to be installed in a location that would have been affected by the return air velocity. They were installed in an appropriate location after discussion.
- The outside air temperature sensors were scheduled to be installed on the West side of the building. It was installed properly on the North side of the building.
- The Pre-Heat and Perimeter boiler designs omitted sequencing from the BAS or an external sequencer. An external sequencer was added.
- AHU's were ordered without lighting in the filter and coil sections. Because it was noted prior to the installation, the electrician easily incorporated the change into his work.

The commissioning process proved beneficial to the owner and the ESCO. The following items were discovered after installation. They were addressed and resolved by the team and therefore increased the energy and operational savings to both parties.

- The Chiller sequence of operations called for an alarm at the OWS when a chiller needed to be started or stopped and this was to be done manually by the operators. The Chilled Water and Condenser Water lines did not have the automatic valves required to automate this function. The Commissioning Agent lobbied to automate this function. It was decided to purchase, install, wire and revise the sequence programming to include automatic chiller sequencing.
- During functional testing it was discovered that the existing Chilled Water bypass line was undersized and the Chillers would not remain on line when the AHU Chilled Water valves modulated closed. This was an inherited condition that probably never functioned properly. While allowing the chillers to cycle off during this low load condition was a viable option, it would have created periods of discomfort in the classrooms and offices. We were able to address this issue and it was decided to add three-way valves at two of the far AHU's to provide sufficient chilled water flow during low load conditions.
- VFD's were installed without shielded control wiring, in conflict with the manufacturer's recommendations. The controls contractor had a history of installing unshielded control wiring without incident. We lobbied to have the installation reevaluated. A compromise was struck and most wiring was either re-routed or replaced with shielded wire.
- Because the Pre-heat Boiler system is 35% glycol, the pressure fill system needed to be manually filled. It was installed with no access to City Water for Make-up and no graduated sight-glass to facilitate proper glycol mixing. Also, the automatic make-up pump would not trip on low level in the make-up tank. It was agreed to pipe a hose drop next to the fill station and to add a graduated sight glass to help the operators estimate water and glycol amounts when filling the make-up tank. A low level pump trip, however, was not added.

Lessons Learned

This project showed that commissioning could add value to an ESPC. It helped a large ESCO provider understand and embrace the commissioning process. On the other hand, the project provided an opportunity to learn some lessons. On this particular project, we were fortunate to be involved with an ESCO/Controls Contractor and Engineer of Record (EOR)/MEP Contractor who shared a desire to deliver a complete, high quality product and who, therefore, related to our role with an open mind. In addition, all team members were interested in the workings of the commissioning process and were willing to incorporate, to a certain degree, the details in the day-to-day progress of the project.

Early Involvement

As in any construction and major retrofit project, change management is most cost effective at the earliest phases of the project. This was evident in this project. Our commissioning efforts were most effective when we had an opportunity to review the plans before they became a part of the contractor's scope. Our objective was to "stay ahead of the contractors". Changes that are usually readily agreed to before installation (pipe routing interferences, maintenance clearances, and sensor locations) are probably out of the question during execution. Similarly, commissioning involvement during the submittal phase allows modification at minimal or no cost impact.

Teamwork

The nature of ESPC projects and design build contracts relies heavily on team performance. It was realized early on in this project that we needed to establish ourselves as a "team member" with a third party perspective. We focused first on discoveries that reduced the cost to the team and facilitated the process of system installation. We also focused on proving our value to the EOR. The parties involved were more likely to accept conflict resolution when introduced by the EOR; the EOR owns the liability. We realized that the specifications are living documents in a design build project. The EOR reserves the right to alter the specifications or the installation details rather than to order rework. By helping the EOR discover discrepancies between the plans and the field installation we were able to influence change as part of the team.

Contractual Arrangement

We as the commissioning authority were hired directly by the ESCO. We first saw this as a conflict as we began to navigate the project. We assumed that working for the ESCO would conflict with our desire to serve the owner and protect his/her interest. As we started to delve into the details of the project, it became evident that the drivers for success which include; optimized energy savings, system ease and functionality, and sound construction quality are in the interest of all involved with the project. The ESCO who is required to remain engaged with the project for a long term is in fact an owner by proxy. Allowing the commissioning authority to operate as intended reduced the potential for disputes and claims and therefore the ESCO's

financial risk associated with that. Demonstrating the benefits of commissioning in the details of the project, allowed us to fulfill our role within the contractual arrangement used.

Looking back at the progression of this project, which seemed typical of an ESPC, we still see the issue of integrating commissioning during project development as unresolved. Ideally, commissioning during project development incorporates both retro-commissioning and commissioning. In brief, the process would include retro-commissioning the existing system to clearly establish the conditions and capabilities of that system, and to identify the necessary scope required to make the system ready to accept energy efficiency measures. The process would also include typical design phase commissioning techniques such as design reviews and commissioning specifications. With the structures available for ESPC, it is difficult to incorporate such tasks before contract award and without any funding for such activities. The owner has chosen the ESPC route because of their lack of funds and because the ESCO is apprehensive about investing their resources. In our opinion, this is an area for stakeholders such as NAESCO, State legislators, and the Department of Energy (DOE) to explore. The solution could be that the Investment Grade Audit becomes a retro-commissioning scope and that a commissioning authority is hired directly by the owner even if paid by the ESCO.

Conclusion

Applying commissioning to an ESPC project was a challenging, yet rewarding, endeavor. By demonstrating the benefits to the parties involved, and exhibiting teamwork behaviors, we were able to operate with integrity and to serve the owner's interest within the given contractual arrangements. As a result, a large ESCO provider has embraced the commissioning process and is enthusiastic about incorporating it in their ESPC projects. Also, a large higher education institution is convinced of the benefits of commissioning and has adopted commissioning in all ongoing projects; new construction, renovation, and ESPCs.

Commissioning during scope development remains as an unresolved issue. The timing and funding of such activities fall outside the typical progression of an ESPC and therefore will be a challenge to perform. We recommend that ESPC stakeholders explore this issue and address it within the existing ESPC structure. Meanwhile, owners and ESCOs need to be aware of the risks involved, and to explore options to incorporate commissioning during scope development on a case-by-case basis.