

ENERGY PERFORMANCE CONTRACTING FOR NEW BUILDINGS

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ENERGY PERFORMANCE CONTRACTING FOR NEW BUILDINGS

EXECUTIVE SUMMARY

The way buildings are typically designed, constructed and operated offers little incentive for energy efficiency. Architect/Engineer firms are often paid a flat fee or a percentage of construction costs, an arrangement that discourages them from spending extra time on innovation and efficiency. Performance contracts provide an incentive to design and construct efficient buildings, making it worthwhile for designers to integrate energy efficiency into the plan from the start, when it is possible to have the largest impact with the least effort and cost.

Recent interest in performance contracting comes from the recognition that the market has failed to pursue large economic opportunities in building energy efficiency. This failure stems from the inability of design professionals to explore alternatives due to the limited time allowed by contracts awarded from low bids.

Performance contracting, as described in this guide, is different from typical energy service company projects because it is applied to new construction rather than retrofits. The long term impact of improving the energy efficiency of new buildings is enormous. Worldwide, over 3 billion square feet of new commercial buildings were constructed in the last decade, and that rate is expected to increase.

In this guide you will find information that can help you decide if performance contracting is right for your project, and a step-by-step guide to creating performance contracts.

PERFORMANCE CONTRACTING

- Promotes better integration between architects, engineers, builders, owners and operations and maintenance staff
- Provides an incentive to the design and construction community to go beyond minimum code requirements
- Can provide excellent return on investment with low risk

INTRODUCTION

Currently, many design fees are either a percentage of the total construction budget or a flat rate. This has the effect of emphasizing speed and discouraging additional work such as improvements to overall building performance. When extra effort is expended, architect/engineer (A/E) firms focus on highly visible building features such as exterior and interior finishes because they know these will be appreciated by the owner.

Additionally, A/Es fear litigation from non-standard or undersized design. From the mechanical engineer's point of view, it is a good idea to grossly oversize a system since there is no incentive for appropriate sizing, and an undersized system is a huge liability. Since the lowest bid for design services often wins, architects and engineers spend little time calculating appropriate equipment sizes or investigating the energy benefits of one glazing type over another. As a result, equipment is grossly oversized at the expense of energy efficiency.

Energy performance contracting is fundamentally a means of improving energy efficiency in new buildings. The owner who initiates a performance contract relationship is seeking to provide an incentive to the A/E to design an energy-efficient building.

With performance contracting, the investment in energy efficiency consists of additional professional services for design, energy analysis, building commissioning, and coordination between disciplines. These additional services result in a more energy-efficient building. The cost of the services is recovered through future energy savings.

In contrast with new building performance contracting, energy service companies primarily do retrofit work. While the basic intent is similar, new buildings pose a problem that does not exist with retrofits. Chiefly, the building isn't built yet, so there is no base case level of energy performance. To solve this problem, a computer model of the building may be developed with energy simulation software like DOE-2. A computer model can give both a base case and, after modeling a reasonable package of energy efficiency measures, a target level of energy performance.

Lighting, water heating and space conditioning are the three energy end-uses that should be included in most energy performance contracts. These end-uses depend on building operating schedules, thermostat settings and other usage patterns. Once the building is completed, commissioned and occupied, it is necessary to record these patterns of operation. If the patterns are significantly different from what was assumed in setting the target, then the target is adjusted.

TABLE 1. BENEFITS OF PERFORMANCE CONTRACTING

OWNER

- Reduce total building lifecycle cost
- Increase rent revenue or sale price due to lower operating costs
- Green building image helps marketing
- Efficient systems tend to be higher quality (maintenance and replacement cost savings)

ARCHITECT/ENGINEER

- Incentive for a low energy cost design
- High performance, "green" building in portfolio
- Clearly stated performance goal before work begins helps streamline process

CONTRACTOR

- Additional design work generally creates clearer and more specific construction plans
- Source of compensation for nonstandard components and energy-saving designs
- Possible influence and input during design process
- Incentives for proper commissioning (fewer callbacks)

OCCUPANT

- Energy efficient, productive, and enjoyable workspaces

COMPETITIVENESS

The ability to build and operate buildings that incorporate the best energy design features is becoming an increasingly important competitive factor for building owners and developers.

—E SOURCE, INC.

Measurement and verification (M&V) of building performance is an essential element in new building energy performance contracting. M&V is needed first of all to determine if the building meets the target. It is also needed to record building operation patterns. M&V can be provided through the building management system, through stand-alone instrumentation or both. The entity responsible for M&V should be independent and acceptable to both the owner and the A/E or design/build contractor. Independence is critical, as penalties and rewards may hinge on the M&V findings.

Performance contracts are included as part of the general agreement between the owner and A/E. Having the performance target available from the start makes it possible for the A/E to effect meaningful changes in fundamental building characteristics such as the form and siting. Simple changes like proper solar orientation can have a large impact. Increasingly, standard agreements are made modular to allow for additional contract language. See AIA Standard Agreement B141 rev. 1997, for example.

A simple timeline for performance contracting is shown in the table, below.

TABLE 2. PERFORMANCE CONTRACTING TIMELINE

Project Phase	Action
Pro Forma	-
Programming	Set-up Performance Contract Hire A/E or DB
Schematic Design	Performance Check
Design Development	Performance Check
Construction Document	Performance Check (3 times) (OPTIONAL) First Payment to A/E
Construction Administration	-
Commissioning	(OPTIONAL) Second Payment to A/E
Occupancy	Measurement and Verification Final Evaluation Final Payment to A/E or DB

Elements of a Performance Contract

There are a wide variety of contractual arrangements between building owners, architects, engineers, contractors, suppliers, value engineers, construction managers and others. The following section, Building Delivery Systems, describes in detail how performance contracting works in each of the usual contractual arrangements. In this section, the common elements to all performance contracts are discussed.

Each energy performance contract must be tailored to the conditions of a specific project, but all performance contracts should have four basic elements:

- A clearly stated target or performance goal.
- A method to evaluate performance during the design process.
- A protocol for measuring performance after the building is constructed, commissioned and occupied.
- A/E compensation (or design/build fee) that is partly contingent upon meeting the performance goal.

Performance Goal

Energy performance contracting holds the promise of helping fund the development of profitable, energy-efficient buildings. A clearly stated goal is at the core of every contract. In this case, the performance target is that goal, and it must be developed concurrently with the building program and before a contract is negotiated with the A/E.

There are several ways to arrive at an acceptable performance target. Multi-building developers may be able to use measured performance of existing or recently constructed buildings for a base case. However, computer modeling is more often used. If the target is based on computer modeling, then it is easy to make adjustments for building operating patterns, weather and other factors.

A figure of merit for energy performance will need to be identified early in the process. Annual energy cost is the most common currency. Another option is to use energy, expressed either as Btu or kWh. If energy is used, then it will be necessary to weight gas and electricity use (and possibly other fuels). For instance, reducing the heating requirement by 1 MBtu is less valuable if the heating system uses gas than if it uses electricity.

Evaluation During Design

The A/E team selected for the project must, of course, be willing to accept the responsibilities associated with the performance contract, but also have expertise for computer modeling and building commissioning, or hire a subcontractor who has this experience.

COMMISSIONING

Commissioning is too often the stage in the construction process where the energy saving intent of the design is lost in the real building.

—IPMVP

The A/E must produce estimates of energy performance at several milestones during the process: schematic design, design development and a couple of times during contract documents. The purpose of these estimates is to verify that the building, as designed, meets the target.

Contracts may vary on the requirements for the proposed design, but in any case, the design should meet the performance target. As discussed in the Incentive section, a portion of the A/E's fee often depends on the performance of the design model.

Evaluation of Performance

Measurement and verification is an essential element in building energy performance contracting. M&V is needed first of all to determine if the building meets the target. The monitoring equipment used for M&V is often used in the earlier commissioning process to help optimize equipment performance. M&V can be provided through a building management system, through stand-alone instrumentation or both.

The entity responsible for M&V should be independent and acceptable to both the owner and the A/E or design-build contractor. This is important since penalties and rewards may hinge on the M&V findings.

The performance of the building is tested through computer modeling during the design process, but the real test of performance comes after the building is commissioned and occupied—at the utility meter where it really counts. The first year of building operation is often rather unstable as the tenants are moving in and getting settled, so the second year is generally used to verify performance and for calculating bonus fees or penalties.

A detailed description of the M&V process is given in the Step-By-Step Guide to Creating A Performance Contract later in this guide. Also, see the *International Performance Measurement and Verification Protocol* published by the Department of Energy. The IPMVP is an excellent resource for learning about M&V procedures, examples, and how to avoid typical problems. The resource list at the end of this guide has information on how to get this document as well as a number of other useful reports.

Incentives

An incentive is offered for success and a penalty for failure. The incentive can be viewed as the net present value of the energy savings over a fixed time period, usually in the neighborhood of five years. Similarly, the penalty can be viewed as the net present value of the increased energy cost over that same time period.

Picking an appropriate compensation mechanism is crucial to the success of an energy performance contract. The risk taken by the A/E can range from uncompensated time to a penalty payment for not meeting the minimum level of

performance. Since the final fees are not paid until the building performance is evaluated at the end of the second year of operation, both the risk and the reward should be adjusted for the time value of money.

Specific incentive schemes are presented in Applications on page 6.

What to Expect From A Performance Contract

This section is basically a summary of what to expect from an energy performance contract project. Two questions are answered: “How does performance contracting affect the timeline of a project?”, and “What are the benefits and risks to the owner of using a performance contract?”.

Project Timeline

When initiated early in the design process, performance contracting should not add any time to a project. All of the additional design and analysis services are performed concurrently with other design services. The same does not hold true for performance contracts initiated later in the design process. Starting energy efficiency improvements late either means some opportunities will be lost, or some of the work, such as siting and shell design, will have to be redone, increasing costs and adding time.

The value of starting early cannot be overemphasized. Retrofits and late design changes are usually limited to HVAC equipment selection, lighting equipment changes, and possibly glass type. These of measures save energy, but they have a relatively low rate of return. The most cost-effective measures happen early on, and affect characteristics like building orientation, window size and placement, shading, space planning. Many of these measures cost nearly nothing—sometimes they even cost less than the base case—but each have the potential of saving a lot of energy.

Summary of Benefits & Risks

The benefits of performance contracting to the owner can be distilled down to three important points:

- Reduced energy bills = Lower operating cost
- Increased value to tenant from improved lighting and HVAC commands higher rents
- Green image improves marketing

The downside to performance contracting consists of two factors:

- Possible increase in first costs to pay for energy efficiency measures
- Increased management duties to oversee energy efficiency work

APPLICATION TO SPECIFIC BUILDING DELIVERY SYSTEMS

Performance contracts consist of additional language attached to the standard agreement between an owner and the party responsible for design. The methods used for building delivery range from design-build teams and construction managers to owner-architect-contractor triangles to situations in which the tenants are responsible for space improvements. For each of the several common building delivery systems, this section describes the contract relationships, the development of a target, outlines techniques for verifying performance, and identifies appropriate incentive schemes.

Design-Build

There are many variations of the design-build (DB) model, but in general, the building owner signs a contract with a design-build contractor to provide a building, meeting a certain specification, at a fixed or negotiated price. The DB entity has responsibility for designing, constructing, commissioning and delivering a building which meets the requirements established in the agreement. The owner generally employs one or more advisors to prepare the specification for the building. The detail with which the specification is developed is one of the principle ways that DB contracts vary. The specification can range from schematic design drawings (at the most detailed end) to a brief building program and specification.

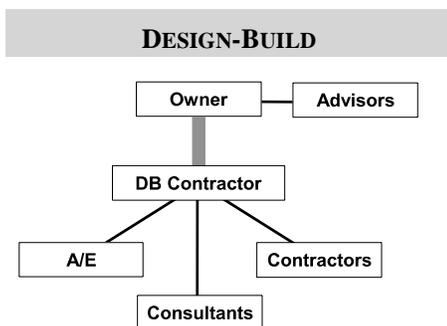
There is a precedent for DB performance contracts funded through the Performance Based Fees project: the Oakland administrative building.

Contract Relationships

The figure at left shows the typical contractual organization of a design-build project. Each of the lines represents a legal contract. With DB projects, the performance contract is between the owner and the DB contractor (heavy line). The DB contractor may negotiate performance contracts with one or more of its subcontractors, but the owner need not concern itself with the specifics of such contracts. The owner's primary concern is with the end result, for which the DB contractor is responsible.

Performance Target

For design-build projects, the performance target is specified for the whole building. This gives the DB contractor the flexibility to achieve the required energy savings using any means.



The first step is to choose a currency for measuring savings. Rather than choosing energy units like kWh or MBtu, it is better to use dollars since this frees the DB contractor to capture any kind of utility savings. Savings may come from cuts in electric or gas energy, electric demand reductions or load shifting, load prediction or control.

The performance target is then the expected utility cost of operating the building if it is built with energy-efficient technologies. Usually, this dollar figure is obtained through analyzing the energy use of the building with a computer model.

If a computer model is used, it is developed by the DB. The model simulates the energy consumption of the expected building with a number of energy-efficient features added. The choice of these features depends on the building type and use. The owner and the owner’s advisors determine this list of efficient features before a contract is negotiated with the DB.

Design-build teams have a high degree of control over the energy cost of the finished building. They are responsible for design, construction management, and in many cases, construction financing. This level of control should be reflected in the stringency of the performance target.

Design Evaluation

Design evaluation is best done by having the owner’s advisors review the hourly computer simulation model developed by the DB. Computer models are useful because factors beyond the designer’s control can be screened out.

Weather and occupancy schedules are two important uncontrolled factors. If a computer model is not used, it is important to screen out these factors through some other means. This could involve spreadsheet adjustments based on measured data, however, to be fair, the methods for adjusting data must be worked out in detail ahead of time. Because of the ease of screening out these factors with computer modeling software, programs such as DOE-2 are widely used for design evaluation.

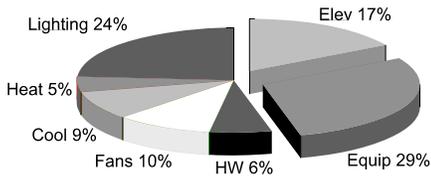
Throughout design and construction, the DB produces regular reports with estimates of the annual building energy cost. The estimates are used by the owner to monitor progress toward the performance target, and to help evaluate the design at each stage of development.

Performance Verification

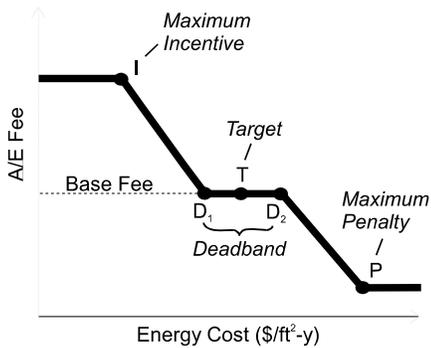
Because buildings are generally not fully occupied for the entire first year of operation, the final evaluation of the building performance is done at the end of the second year of operation. At that time, the performance target is adjusted for operating schedules, equipment loads, elevator energy, actual weather, utility rates and other factors that are not within the control of the design-build contractor. Included energy uses are heating, cooling, fans, hot water, and lighting. A typical split of energy end uses for an office in a temperature climate

TABLE 3. DATA NEEDED FOR EVALUATION	
WEATHER DATA	
	Outdoor Drybulb Temperature
	Heating Degree Days
	Cooling Degree Days
	Total Horizontal Radiation
ENERGY PROVIDER BILL	
	Total Monthly kWh
	Monthly Peak kW
	Monthly therm
	Monthly Energy/Demand Charge
OTHER DATA	
	Energy Consumption of a Particular System/Zone (i.e., lighting alone)
	Occupancy Schedule

TYPICAL OFFICE ENERGY USE



BASIC INCENTIVE STRUCTURE



are shown in the figure at left. About 54% of building energy use is considered in the performance contract. About 46% (equipment and elevators) is treated as a pass-through.

Incentives

To create an energy-based performance fee structure, first identify the target in units of \$/ft²-y. Referring to the diagram at left, the base fee, which includes all the regular design fees plus the expected cost of doing the additional performance contracting work, is earned when the target is achieved.

Identify the maximum incentive possible for completing a building that performs better than the target, and the maximum penalty for a building that performs worse than the target. Neither of these limits are necessary from a standpoint of economics or engineering, since the benefit of an efficient building is only limited by the value of a building that consumes no energy. Likewise the energy cost of an inefficient building has no real limit. Nevertheless, experience has shown that all parties to the contract tend to prefer including these limits.

Next, in recognizing that the evaluation of the building energy performance is not without error, a deadband should be added around the target. Typically, the deadband is ±10 to 15 percent of the target.

Finally, select a scheme for prorating the incentive and penalty for performance outside the deadband but which falls short of the target. Essentially, this is selecting a slope for the lines from D₁ to I and D₂ to P in the Basic Incentive Structure figure at left.

Owner-Architect-Contractor

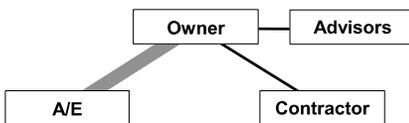
Traditionally, the owner hires an architect/engineer (A/E) team to prepare a complete set of plans and specifications. A contractor is then selected to construct the building, often on the basis of lowest cost. The owner, architect, and contractor have a triangular arrangement, although there is no legal contract between the architect and the contractor.

Energy performance contracting examples using this building delivery system include a high school in Portland and a state office building in Austin.

Contract Relationships

The performance contract is negotiated between the owner and the A/E team. In order to accept responsibility for the energy performance of the building, the A/E scope of services are expanded to include a greater role in energy analysis, construction administration, and building commissioning.

OWNER-ARCHITECT-CONTRACTOR



Performance Target

Two levels of energy performance are identified. The first (base) represents minimum compliance with applicable codes and standards or typical practice. The second level (target) is what can be reasonably achieved with integrated design and construction. Advisors to the owner help establish these levels of performance.

The performance target is the expected utility cost of operating the building if it is built with cost-effective, energy-efficient technologies. Usually, this dollar figure is obtained through analyzing the energy use of the building with a computer model. The computer model will necessarily be rough because at this point the building design is still in programming. For this reason, a base case model is often developed, and the target is expressed as a percent reduction to the base case.

The base case model consists of the base case building calibrated to the most recent utility billing history. For new construction, the base case is defined by the building that minimally complies with an energy standard such as ASHRAE 90.1.

Once the base case energy cost is agreed upon, at least two numbers should be looked at in determining a reasonable performance target.

First, the energy consumption of similar building types in the same climate is a useful gauge of how much more efficient a "typical" building is compared with minimum code requirements. Data of this type may or may not be available.

Second, a group of energy efficiency measures should be applied to the base case model to determine the \$/ft² energy cost in a reasonably efficient building. This target should only include those measures which are roughly cost effective. Also, only measures over which the A/E has some measure of control should be included. In most cases this includes HVAC, insulation, fenestration properties (other than appearance), lighting, and hot water. The energy cost of this simulated building can be used for the performance target, although the target should be expressed as a fixed percentage savings over the base case.

In all cases, the performance should be achieved, or nearly so. If the A/E is not confident the target can be achieved for a reasonable effort, the target should be renegotiated.

Depending on the stringency of the code used to define the base case, reasonable performance targets typically range from saving 25 - 60 percent compared with the base case. This range of savings does not represent the actual savings because typical practice is usually somewhat better than codes require.

Design Evaluation

Before design evaluation can begin, the A/E is responsible for developing a computer model with an energy simulation program such as DOE-2. Minimally

compliant wall, roof, floor, and window constructions, and energy code standard schedules are used to model the base case building.

The A/E's proposed design is viewed by the owner and the owner's advisors as a set of changes to the base case model. Throughout design, the performance of the proposed building can be compared with the base case to estimate savings.

Performance Verification

Like with design-build, data from the second occupied year are used to verify the performance of the building. At the end of the second year, the performance target is adjusted for operating schedules, equipment loads, elevator energy, actual weather, and utility rates.

Incentives

Because of the A/E's limited ability to control construction quality or improve the design during construction—for instance, when problems are encountered or construction engineers see a better solution—limited liability should be placed on the A/E. No penalty is recommended beyond the risk of uncompensated time. While the risk is limited, the benefits are too, from the recognition that a design which performs well in a computer model is not guaranteed to perform as well in reality. The owner must hold back some of the possible incentive to mitigate this risk.

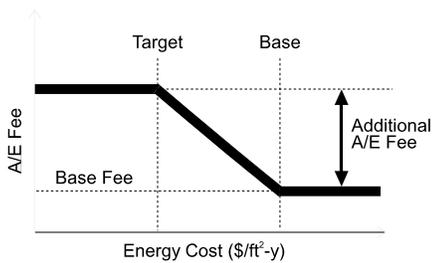
Depending on the fee structure, the A/E may be interested in surpassing the specified performance target to capture additional payment. At a minimum, however, the A/E should be sufficiently motivated to pursue the target level of performance.

The Basic Incentive structure has no penalty other than uncompensated work. The base fee is for standard design services, and does not include any fees for energy efficiency work.

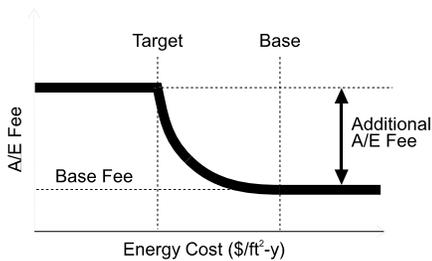
It is also possible to weight performance near the target more heavily. With the Weighted Incentive, the A/E has a strong incentive to actually achieve the performance target, since the incentive drops off rapidly with underperformance. It is crucial that the A/E is confident that the target can be met when operating under the Weighted Incentive fee structure, because otherwise there is little motivation to spend additional time improving the building.

Historically, the time lag between the initial design services and payment has been long because of the number of steps which must be completed before measurement and verification of the occupied building can take place. Especially with small firms, with less ability to self-finance, the 2-4 year time lag is just too long. Some variations are possible that still retain the basic performance approach, while releasing some funds earlier.

BASIC INCENTIVE



WEIGHTED INCENTIVE



In addition to the final measurement and verification of savings, there are at least two logical times when payments can be made to the A/E. The first time is upon completion of a design that meets the energy performance target when simulated. The second time is upon completion of construction with no significant changes to the last acceptable design. Any combination of these payment dates is possible. However, most firms will want to see some compensation for their efforts before the end of second occupied year. To retain the essential element of performance contracting, the final payment should definitely be contingent on measured data of the occupied building.

TABLE 4. SAMPLE PAYMENT SCHEDULE

At Completion of...	Percent Paid of Estimated Incentive	Estimated Incentive (\$)	Dollars Paid (\$)
Design	20%	\$500,000	\$100,000
Construction	30%	\$450,000	\$135,000
M&V	50%	\$300,000	\$150,000
Total			\$385,000

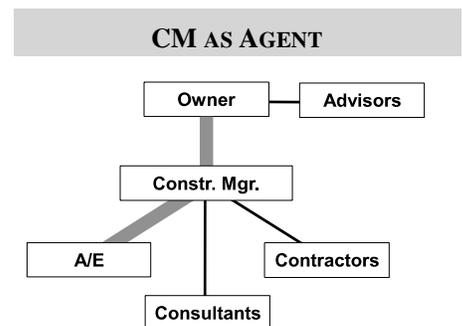
Construction Manager

Contract Relationships

Construction management (CM) firms can take on several different contractual roles from agent to contractor to advisor.

The CM can be an agent of the owner, both overseeing and managing the design and construction in much the same way as a design-build team. The CM is financially responsible for the project, manages the design, construction, and commissioning; and the architects, engineers, consultants, and contractors all have contracts with only the CM, and not the owner. Because of this controlling role, it is natural for the owner to make the energy performance contract with the CM. It is then up to the CM to make an additional performance contract with the A/E if that is desired. From the owner’s point of view, the performance contract is the same as design-build. See the Design-Build section above for information on how to create a performance contract with a construction manager acting as an agent.

The CM can act as general contractor, overseeing construction and managing contracts with subcontractors. In this case, the CM has no control over the design, and very limited ability to improve energy efficiency. The performance contract is therefore only between the owner and the A/E. For the purposes of the performance contract, this situation is identical to the traditional owner-



architect-contractor method. See that section above for details on how to develop a performance contract.

The CM can also act solely as an advisor to the owner. This is usually done on complex projects where the owner needs assistance managing the project details and keeping construction on budget. No contracts are made between the CM and the A/E or between the CM and the contractors. Therefore, contractually, this is the same as the traditional owner-architect-contractor model, and details on how to form a performance contract can be found in that section.

Speculative Buildings: A Special Case

Ideally, the performance goal should be expressed for the entire building since this encourages integrated design. While this is possible for owner-occupied, design-build projects, it is very difficult or impossible for speculative buildings. There are just too many architects, engineers and contractors responsible for various inseparable and interactive parts of the overall performance of the building. It is important to identify the *deliverer* of energy performance.

It is unreasonable for the base building architects to accept responsibility for the overall energy performance of the building, as they are mainly responsible for the design of the building envelope, which does not use energy directly (it affects loads on the mechanical system). In some instances, the mechanical engineer is under contract with the architect, in which case the architect can hand down specific requirements for the mechanical system that take into account their envelope design. However, in some cases the mechanical engineer is under separate contract to the owner, construction manager, or design-build group. In these cases, the architect has little or no influence over the systems and likewise the mechanical engineer has no influence over the envelope design. On top of all this, a very large fraction of the lighting and equipment loads are determined by tenants—something neither designers nor builders have any control over.

The very nature of speculative buildings makes it difficult or impossible to apply whole-building performance contracting. Instead, it is necessary to write contracts for the energy performance of building subsystems. Some integrated design can still occur, but it must be performed in advance of setting up the performance contracts (e.g., the relationship between high performance glass and perimeter heating systems). Additionally, tenant agreements can be modified to encourage tenants and their A/E teams to design energy-efficient spaces.

Contract Relationships

There are really two separate performance contract relationships that exist with speculative construction. The first is between the owner and the A/E, and the second is between the owner and the tenant.

In the first case, the A/E agrees to a performance target and incentive structure that is almost the same as in the traditional owner-architect-contractor model, except that in this case the A/E is only responsible for improvements to the building shell and HVAC system.

With the second contract, the owner and tenant make an agreement that the tenant will receive a larger tenant improvement (TI) budget if certain minimum efficiency standards are met. Usually this includes efficient lighting and supply air outlets.

Performance Target: A/E

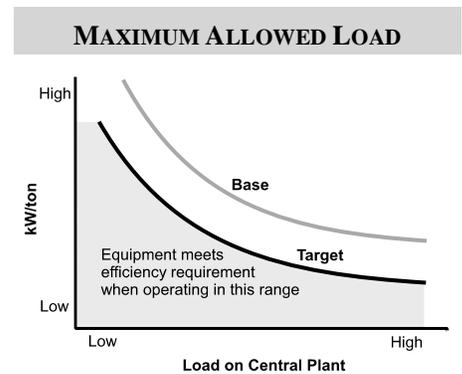
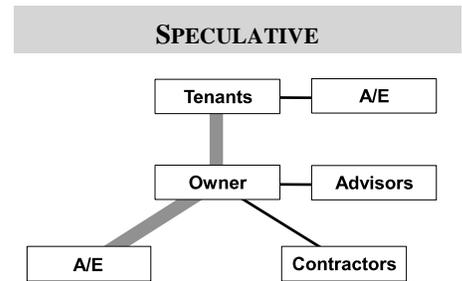
Two measures of performance can be addressed in the base building performance contract with the A/E: the efficiency of the heating and cooling central plant, and the performance of the building envelope.

A reasonable HVAC performance target is for the overall system efficiency of the central plant. This is the sum of all the energy used by the plant divided by the load on the plant. Both can be accurately measured with a combination of flow meters, temperature sensors and electric sub-meters. The load is the independent variable. It depends on what the tenants do (e.g., the lighting and equipment power they install and their work patterns). The performance contract with the A/E, however, can specify a maximum energy use for each load condition as shown in the figure at right.

The performance requirements for the building envelope may be expressed in terms of heat loss through the building envelope, infiltration, daylight factor and glazing efficacy. These can be verified in situ by isolating portions of the building envelope and performing tests.

Performance Target: Tenant

Several incentives may be implemented to encourage the tenants to install energy-efficient lighting and equipment. The first step is to develop a design standard for tenant improvements. The standard can be expressed as a maximum lighting power density, equipment power density, etc. Tenants are then offered a larger tenant improvement allowance if they design to the standard. After the tenants have moved in, the amount they pay for energy costs should be separated from the base rent so that they are encouraged to continue to operate their spaces in the most efficient manner.



Design Evaluation

Depending on how the target is specified, evaluation can be made through the use of a computer model or by checking the design against a component specification.

For targets that apply to whole systems, creating an hourly computer model is useful in order to screen out weather and occupancy variations. The computer model is developed by the A/E with an energy simulation program such as DOE-2. No base case model is needed, as the model is simply a representation of the actual design.

For component specification targets, the design is simply checked to make sure it includes an appropriate specification within the allowed budget.

Performance Verification

As with the other building delivery methods, data from the second occupied year is used to verify the performance of the finished building.

For verification of the performance for the base building, the measured energy uses should include pumps, fans, chillers, cooling towers and other auxiliary equipment. These measured data will be used to find the actual energy performance (usually in $\$/\text{ft}^2\text{-y}$).

Verification of the tenant improvements can be made in several ways, depending on the specification. Take lighting, for instance. A simple lighting power density calculation can be made by dividing the total maximum measured lighting power by the net area of the tenant space. HVAC air outlets can also be verified. A check of the outlet manufacturer's literature should supply the efficiency, and a visual inspection during construction can verify proper installation of the specified outlet.

Incentives

Like the traditional owner-architect-contractor method, the A/E does not have sufficient control over the construction process to warrant a financial penalty for not meeting the performance specification. Risk is limited to uncompensated time. The prorating options presented in the traditional Owner-Architect-Contractor section above, are also possible in this case.

With tenant agreements, a simple incentive arrangement is best. If the tenant manages to finish their space to the design specification, then they receive the additional improvement allowance in a lump sum. If they cannot, no additional allowance is awarded.

CASE STUDIES

While not yet mature, performance contracting has been used in a number of projects, and the experience continues to grow. This section presents brief case studies of city administration buildings in Oakland, California, a skyscraper in Times Square, a government building in Austin, Texas, and a high school in Portland, Oregon.

TABLE 5. PERFORMANCE CONTRACTING CASE STUDIES

Project	Delivery	Description
Oakland Administration Buildings	Design-Build	420,000 ft ² in two buildings - a new 6-story and an 8-story addition to a historical building.
Four Times Square	Speculative	1.5 million ft ² high-rise office building in New York's Times Square.
R.E. Johnson State Office	Traditional A/E	275,000 ft ² state office building. Early analysis showed \$100,000 potential savings.
North Clackamas High School	Traditional A/E	Extensively daylighted and naturally-ventilated. Early analysis showed \$50,000 potential savings.

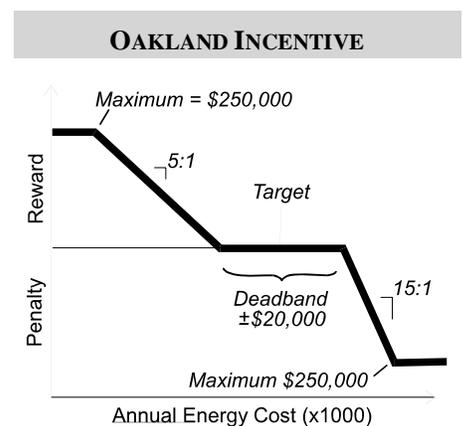
CITY ADMINISTRATION BUILDINGS

OAKLAND CA

The city has a contract with a DB firm to design, engineer, construct, commission and deliver 450,000 ft² of office buildings for a fixed price. The buildings are a combination of historic renovation and new construction. The agreement calls for a minimum energy performance expressed in \$/ft²-y.

The performance target ranges between \$1.00 and \$1.40/ft² depending on actual operating schedules, equipment loads, elevator energy, weather, utility rates and other factors that are not within the control of the DB. If measured energy use is within \pm \$20,000, the target is considered met. If energy use is outside these bounds, the city is compensated or the DB rewarded according to the incentive curve at right.

Energy use will be monitored through a building-wide energy management system, and energy use during the second year of operation will be used to determine the reward/penalty.



Throughout design development, evaluations were made. Upon completion of the design work, the design was estimated to meet the target. Currently, the building is being commissioned. The building will be occupied in the first quarter in 1998.

FOUR TIMES SQUARE

NEW YORK NY

Four Times Square is a 1.5 million ft² speculative, high-rise office building. The developer has separate contracts with the architect, the ME/EE and a construction manager. This group will design and build the shell and core. Interior finishes, lighting and terminal HVAC will be completed by the tenants and their separate A/E teams.

This is a mock performance contracting project because there are no actual incentives or penalties. A performance contracting scenario was created anyway to learn how speculative construction should be approached.

In this hypothetical scenario, the performance target for the ME is specified in terms of HVAC system efficiency. Loads are monitored through chilled water and hot water flows and temperatures. Given these loads, the HVAC system is expected to operate at a specified level of performance.

The performance requirements for the building envelope would be expressed in terms of heat loss through the envelope, infiltration, daylight factor and glazing efficacy.

To address the large impact tenants have on the energy consumption of the building, a tenant performance target would be developed that takes lighting and equipment power density into account. A bonus tenant improvement allowance would be offered for tenants who meet the target. The developer would provide energy design assistance to tenants, and rent and utilities would be kept separate to provide an incentive for tenants to reduce utility costs.

R.E. JOHNSON STATE OFFICE BUILDING

AUSTIN TX

The delivery system is more traditional for this 275,000 ft² state office building. A full-service A/E provided complete plans and specifications to the owner. Under Texas law construction of the project was competitively bid.

The performance contract is between the state and the A/E. In order to accept responsibility for the energy performance of the building, the A/E scope of services was expanded to include a greater role in energy analysis, and construction administration. Details of the performance contract are still being negotiated.

The construction contract was recently awarded, and construction will begin shortly. Performance will be measured through utility bills and the EMS after the building is occupied.

NORTH CLACKAMAS HIGH SCHOOL

PORTLAND OR

The school board has a contract with an A/E to design the building and produce contract documents. The project will then be bid.

An additional fee has been negotiated for the expanded role of the A/E. The additional services will include energy analysis during the design process, greater responsibility in construction administration, and building commissioning. The additional fee will be paid through energy savings, relative to a base level of performance, which is defined in the contract as minimum compliance with the Oregon state energy code.

The project stalled after schematic design because a bond measure needed to pay for construction was not approved. The local utility is interested in the project and may participate in some manner.

STEP-BY-STEP GUIDE TO CREATING A PERFORMANCE CONTRACT

Follow this step-by-step guide to create a performance contract for your project. Two contracts covering whole-building energy efficiency and one covering system components are included in this section. The first whole-building contract covers agreements between an owner and an A/E firm in traditional owner-architect-contractor arrangements. The second whole-building contract covers agreements between the owner and design-build firms or contract managers acting as agents.

The language offered in this section is not intended to be used “as-is” in an actual contract. Rather, it should be used as the starting point for a discussion between the owner and performance contractor. As with all contracts, the language offered in this section should be reviewed by an attorney before signing.

Organization of Contract Sections

Section 1. Main Contract

Option 1. Whole Building: Owner-Arch.-Contractor Contract

Option 2. Whole Building: Design-Build Contract

Option 3. Component Contract

Section 2. Computer Modeling

Section 3. Corrective Action

Section 4. Commissioning

Section 5. Measurement and Verification Contractor Responsibilities

Section 6. Measurement and Verification Performance Contract

Note: For contract manager projects, use Option 1 when the CM is acting as an advisor to the owner or as a contractor. Use Option 2 when the CM is acting as an agent of the owner.

Whole Building Contract Owner-Architect-Contractor

When To Use

The first whole-building contract is between the owner or contract manager and the A/E (or any designer not directly involved with construction). It is used for projects in which the A/E has the ability to design or modify the design of basic building elements such as shell characteristics and fenestration, as well as building systems, including lighting, hot water, HVAC. If this is not the case, then a component contract should be used.

Contract

The following contract language is indented and in non-serif font to separate it from the commentary and usage instructions.

Because of the wide range of project types and advances in available building efficiency technologies, a single contract cannot encompass every possible energy-saving measure or relationship. It is intended to be used as a guideline—a detailed one, but also one which can be modified to fit new situations and capture new opportunities.

1. **Whole Building Energy Performance Contract.** (Owner) is committed to implementing architectural, lighting, HVAC and energy management systems that operate efficiently, provide a high quality of occupant comfort, and are easily maintained and serviced. For (Project) (the “Project”), this will be achieved through an energy performance contract between (Owner) (the “Owner”) and (Architecture/Engineering Firm) (the “Performance Contractor”). This agreement supplements the professional services agreement between the owner and the Performance Contractor. The terms of the supplementary agreement are described below.

It is useful to express the target as a percent of the base for simplifying calibration of the computer simulation model. By doing this, only the base case needs to be adjusted to match measured data.

- 1A. Both the Owner and the Performance Contractor agree to a base level of energy performance of \$ /y-ft² and a target level of energy performance of % of the base. The base level of performance represents minimum compliance with applicable codes, while the target level of energy performance is the expected performance level, based on the project budget and commitments to energy efficiency by the Owner and the Performance Contractor. Both the base and target levels of performance shall be calculated using the gross floor area (GSF) of the building.

Section 1. Whole Building Performance Contract: Owner-Architect-Contractor

- 1B.** The Performance Contractor agrees to provide computer modeling services throughout the design and construction of the Project. If the Performance Contractor does not have the skills to provide this service, it is obligated to hire a computer modeling consultant.

Paragraph 1C is intended to make clear that the purpose of this endeavor is to design a building that consumes energy at a cost no greater than the target. The Performance Contractor should feel confident that this can be achieved and that the incentive is sufficient to warrant trying. In essence, this is a statement of intent. It should not be considered a breach of contract if the Performance Contractor cannot deliver such a design. The Performance Contractor's additional liability beyond that described in the Standard Agreement is limited to uncompensated time.

- 1C.** The Performance Contractor intends to deliver a building design to the owner that meets the target level of performance when simulated.

Paragraph 1D describes the calendar of payments to be made to the Performance Contractor, and lists the deliverables required to secure payment. There are at least three logical times when payment can be made (subparagraphs 1D-1, 1D-2, and 1D-3). Any combination of these is possible, however, the final payment should be contingent on the actual measured performance of the building at the end of the second occupied year.

- 1D.** The owner agrees to compensate the Performance Contractor for additional services according to the following schedule where the term "estimated incentive" is defined in Paragraph 1E.

1D-1. Upon completion of all the construction plans relevant to energy efficiency measures, the Modeler shall use a computer simulation model to estimate the annual energy cost of operation of the building proposed in the completed plans. The Modeler has ___ days to complete this simulation analysis. If the simulated annual energy cost per gross square foot is less than the base case, then the Owner shall pay the Performance Contractor ___% of the estimated incentive.

1D-2. Upon completion of construction of the Project, if the simulated annual energy cost per gross square foot is less than the base case, then the Owner shall pay the Performance Contractor ___% of the estimated incentive.

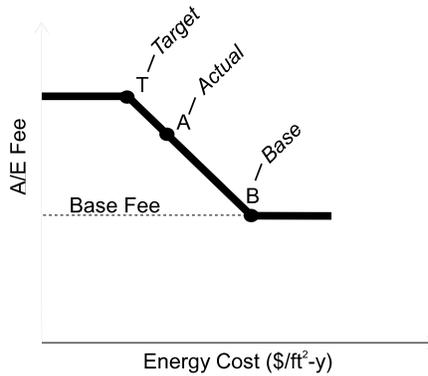
1D-3. At the end of the second year from the date on which the building is first occupied, the energy performance of the building shall be analyzed. The actual incentive will be calculated at that time, and the Owner shall pay the Performance Contractor the remainder of the incentive.

Section 1. Whole Building Performance Contract: Owner-Architect-Contractor

Paragraph 1E specifies the annual energy costs per square foot which define the base case, the target and the deadband. The estimated incentive included here is for a simple linear prorating. Other options are available (see Owner-Architect-Contractor on page 10).

- 1E.** The estimated incentive shall be calculated with this method. The performance points, B and T, shall be specified here. Transfer the base case value, B, and the target percentage, T, from Paragraph 1A above.

B = \$ ___/y-ft² **T** = ___% of B



$$\text{Estimated Incentive} = \$I \left(\frac{B - A}{B - T} \right) \text{ up to } \$I$$

For payments 1D-1 and 1D-2, the energy performance point A is defined by computer simulations performed by the Modeler and calibrated with estimated or standard schedules. For the final payment 1D-3, the energy performance point A is defined by the computer simulation model, calibrated with measured data from the occupied building.

- 1F.** In the event that the building design is modified in a way that significantly affects expected energy performance, the owner and the Performance Contractor agree to re-negotiate the target level of performance. This could result from significant changes to the project budget, through “value engineering,” or through equipment or component substitutions not approved by the Performance Contractor.

Paragraph 1G lists common energy end uses for which the Performance Contractor is responsible. The list is exemplary, and should be customized. It may be that exterior lighting or process loads are included, for instance.

- 1G.** The base and target levels of performance will be adjusted for factors that are not under the control of the Performance Contractor as described in Section II below. Energy uses for which the Performance Contractor is accountable for include heating, cooling, and air conditioning; interior lighting, and water heating.

Whole Building Contract Design-Build

When To Use

The Design-Build Contract is between the owner and the design-build firm. The design-build firm has the ability to control aspects of design and construction, and therefore can accept full risk for the performance of the building. This allows for a higher incentive and the use of a penalty for poor performance. The Design-Build Contract is probably capable of achieving the largest savings because of the ability of the design-build team to improve on the design at all points during design, construction, and commissioning.

Contract

The following contract language is indented and in non-serif font to separate it from the commentary and usage instructions.

1. **Energy Performance Contract.** (Owner) is committed to implementing architectural, lighting, HVAC and energy management systems that operate efficiently, provide a high quality of occupant comfort, and are easily maintained and serviced. For (Project) (the "Project"), this will be achieved through an energy performance contract between (Owner) (the "Owner") and (Design-build Entity, or Contract Mgr.) (the "Performance Contractor"). This agreement supplements the professional services agreement between the owner and the Performance Contractor. The terms of the supplementary agreement are described below.
 - 1A. Both the Owner and the Performance Contractor agree to a target level of energy performance of \$ /y-ft². The target level of energy performance is the expected performance level, based on the project budget and commitments to energy efficiency by the Owner and the Performance Contractor. The target level of performance shall be calculated using the gross floor area (GSF) of the building.
 - 1B. The Performance Contractor agrees to provide computer modeling services throughout the design and construction of the Project. If the Performance Contractor does not have the skills to provide this service, it is obligated to hire a computer modeling consultant.

Paragraph 1C is intended to make clear that the purpose of this endeavor is to design and construct a building that consumes energy at a cost no greater than the target. The Performance Contractor should feel confident that this can be achieved and that the incentive is sufficient to warrant trying. In essence, this is a statement of intent. It should not be considered a breach of contract if the Performance Contractor cannot deliver such a building. The Performance

Section 1. Whole Building Performance Contract: Design-Build

Contractor’s additional liability beyond that described in the Standard Agreement is limited to uncompensated time and the maximum penalty (if any) defined in Paragraph 1E.

- 1C.** The Performance Contractor intends to design, build, commission and deliver a building to the owner that meets the target level of performance.

Paragraph 1D addresses payment. Unlike the traditional owner-architect-contractor model, payment is only made at the end of the second occupied year after measurement and verification.

- 1D.** The owner agrees to compensate the Performance Contractor for additional services. At the end of the second year from the date on which the building is first occupied, the energy performance of the building shall be analyzed. The incentive will be calculated at that time according to the rules in Paragraph 1E, and the Owner shall pay the Performance Contractor the incentive.

Paragraph 1E specifies the annual energy costs per square foot which define the target, the points of maximum incentive and penalty, and the deadband. The deadband should be equal on both sides of the base case (i.e., not favoring incentive or penalty).

- 1E.** The one-time incentive shall be calculated with the following method:

The performance points T, P, I, D₁, D₂, shall be specified here. Transfer the target value, T, from Paragraph 1A above.

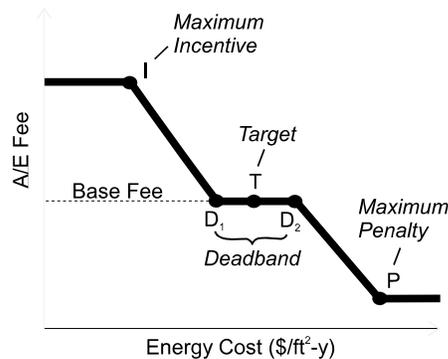
T = \$ ___/y-ft²

The deadband is ± ___% of the target.

The maximum penalty, P, is \$ ____, and the maximum incentive, I, is \$ ____.

The slope of the incentive curve is \$ ____ per \$/ft²-y energy cost savings.

The slope of the penalty curve is \$ ____ per \$/ft²-y energy cost savings.



Section 1. Whole Building Performance Contract: **Design-Build**

Where A is the actual performance of the building,

$$\text{Estimated Incentive/ Penalty} = \begin{cases} \text{if } A > D_2 & \text{(penalty)} & \$P \left(\frac{A - D_2}{P - D_2} \right) & \text{up to } \$P \\ \text{if } D_1 \leq A \leq D_2 & \text{(deadband)} & \$0 & \\ \text{if } A < D_1 & \text{(incentive)} & \$I \left(\frac{D_1 - A}{D_1 - I} \right) & \text{up to } \$I \end{cases}$$

For payments 1D-1 and 1D-2, the energy performance point A is defined by computer simulations performed by the Modeler. For the final payment 1D-3, the energy performance point A is defined by measured data from the occupied building.

- 1F.** The performance target will be adjusted for factors that are not under the control of the Performance Contractor as described in Section 2. Energy uses for which the Performance Contractor is accountable include heating, cooling, and air conditioning; interior lighting; and water heating.

Component Contract

When To Use

The Component Contract is between the owner or contract manager and a designer who is neither directly involved in construction nor able to effect changes to a wide range of building systems. It is used when the designer is limited to a narrow focus such as HVAC components or luminaire selection and placement. If the basic building design is far along before a performance contract is negotiated, this may be the only possible contract.

A variation on this contract is used for tenant improvements in speculative buildings. The owner makes a Component Contract with the tenant to finish their space with lights and HVAC air outlets which meet a minimum performance specification. If the tenant meets the specification, a larger tenant improvement allowance is given.

Contract

The following contract language is indented and in non-serif font to separate it from the commentary and usage instructions.

- 1. Component Energy Performance Contract.** (Owner) is committed to implementing (List systems i.e., lighting, architectural, HVAC) management systems that operate efficiently, provide a high quality of occupant comfort, and are easily maintained and serviced. For (Project) (the "Project"), this will be achieved through an energy performance contract between (Owner) (the "Owner") and (Architecture/Engineering Firm) (the "Performance Contractor"). This agreement supplements the professional services agreement between the owner and the Performance Contractor. The terms of the supplementary agreement are described below.

Or, for tenant agreements:

- 1. Component Energy Performance Contract.** (Owner) is committed to achieving an energy-efficient building through the installation of efficient (List systems i.e., lighting, HVAC outlets) . For (Tenant floor/location) (the "Tenant Space"), this will be achieved through an energy performance contract between (Owner) (the "Owner") and (Tenant) (the "Performance Contractor"). This agreement supplements the rental agreement between the owner and the Tenant. The terms of the supplementary agreement are described below.

The minimum level of performance for each system component is agreed to by the owner and the tenant or A/E firm.

Section 1. Component Performance Contract

- 1A.** Both the Owner and the Performance Contractor agree to a minimum level of energy performance of (Efficiency i.e., kWh per ton-hr of cooling provided) for the (System i.e., lighting, cooling, etc.) , and a minimum level of energy performance of ... for ..., etc.

Alternatively, the performance target can be written as a specification. In this case, no incentive is given if the targets are not met. The actual specification offered is for the building envelope. Similar specifications can be written for cooling, heating, or domestic hot water.

- 1A.** Both the Owner and the Performance Contractor agree to the following energy efficiency specification:
- a. The heat loss through the gross exterior wall is less than Btu/h-°F-ft².
 - b. Infiltration through the exterior envelopes is less than cfm/ft² at 50 Pa of pressure difference.
 - c. The interior mean radiant temperature of the exterior wall is warmer than °F under design heating conditions.
 - d. The average daylight factor at a point 10 feet from the window wall and at a height of 2.5 ft above the floor is at least . The daylight factor is the ratio of daylighting illumination at the reference point to the illumination outside the window.

In all Component Contract cases:

- 1B.** The Performance Contractor agrees to provide computer modeling services throughout the design and construction of the Project. If the Performance Contractor does not have the skills to provide this service, it is obligated to hire a computer modeling consultant.

Paragraph 1C is intended to make clear that the purpose of this endeavor is to design a building that consumes energy at a cost no greater than the target. The Performance Contractor should feel confident that this can be achieved and that the incentive is sufficient to warrant trying. In essence, this is a statement of intent. It should not be considered a breach of contract if the Performance Contractor cannot deliver such a design. The Performance Contractor's additional liability beyond that described in the Standard Agreement is limited to uncompensated time.

For tenant space improvement agreements, leave this paragraph out entirely.

- 1C.** The Performance Contractor intends to deliver a building design to the owner that meets the target level of performance when simulated.

Section 1. Component Performance Contract

For tenant agreements, payment is made when the tenant can demonstrate that their space improvements meet the efficiency requirements laid out in Paragraph 1A. Paragraph 1D is the final statement of the tenant agreement.

- 1D.** The Owner agrees to compensate the Performance Contractor by offering an additional \$ _____ in tenant improvement allowances.

For A/E contracts, Paragraph 1D describes the calendar of payments to be made to the Performance Contractor, and lists the deliverables required to secure payment. There are at least three logical times when payment can be made (subparagraphs 1D-1, 1D-2, and 1D-3). Any combination of these is possible, however, the final payment should be contingent on the actual measured performance of the building at the end of the second occupied year.

Clearly, a contract consisting of solely of equipment specifications can be verified at installation. This type of specification would not be called a “performance contract,” since the contract only specifies the type of equipment and not how it must perform. The contract presented here is intended to be used for setting performance requirements for larger system components, such as the cooling system.

- 1D.** The owner agrees to compensate the Performance Contractor for additional services according to the following schedule where the term “estimated incentive” is defined in Paragraph 1E.

1D-1. Upon completion of all the construction plans relevant to energy efficiency measures, the Modeler shall use a computer simulation model to estimate the annual energy cost of operation of the building proposed in the completed plans. The Modeler has ____ days to complete this simulation analysis. If the simulated annual energy cost per gross square foot is less than the base case, then the Owner shall pay the Performance Contractor ____% of the estimated incentive.

1D-2. Upon completion of construction of the Project, if the simulated annual energy cost per gross square foot is less than the base case, then the Owner shall pay the Performance Contractor ____% of the estimated incentive.

1D-3. At the end of the second year from the date on which the building is first occupied, the energy performance of the building shall be analyzed. The actual incentive will be calculated at that time, and the Owner shall pay the Performance Contractor the remainder of the incentive.

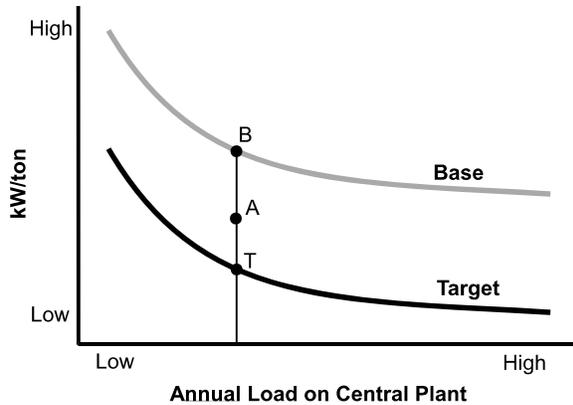
Paragraph 1E defines how the incentive shall be calculated. Each case will be different, depending on which systems are included in the contract. The following is an example for a cooling system:

Section 1. Component Performance Contract

1E. The estimated incentive shall be calculated with the following method:

The base case and target performance curves shall be specified here.

$$C_{\text{BASE}} = \frac{\text{(Base case curve of kW/ton as a function of load on the central plant)}}{\text{(Target curve of kW/ton as a function of load on the central plant)}}$$



A is the actual annual average kW/ton. Point A is used in calculating the incentive.

$$\text{Estimated Incentive} = \$I \times \left(\frac{B - A}{B - T} \right) \text{ up to } \$I$$

1F. In the event that the building design is modified in a way that significantly affects expected energy performance, the owner and the Performance Contractor agree to re-negotiate the target level of performance. This could result from significant changes to the project budget, through “value engineering,” or through equipment or component substitutions not approved by the Performance Contractor.

1G. The target level of performance will be adjusted for factors that are not under the control of the Performance Contractor as described in Section 2. Energy uses for which the Performance Contractor is accountable for include heating, cooling, and air conditioning; and water heating.

Computer Modeling

When To Use

The contract in this section should be used whenever any computer simulation models are needed for development of the target or for performance verification.

Contract

Section 2 deals with calibration adjustments to the computer model. This section can be modified to include only those specific end uses which are relevant to the Project.

The use of the second occupied year to evaluate savings does not guarantee that occupancy or space usage will remain regular throughout the year. If these schedules significantly change, then multiple schedules should be used in the computer model.

- 2. Adjustments to the Computer Model.** The target level of energy performance is determined through a computer simulation model. To create the model, assumptions are made about how the building will be operated and managed. In the event that actual building operation is significantly different, adjustments shall be made to the model. These adjustments are described below.
 - 2A. Computers, Office Equipment and Elevators.** The target level of energy performance is based on assumed peak power and hourly schedules for computers, office equipment, and elevators. Actual peak power and schedules will be measured through the building energy management system or stand-alone dataloggers and the measured values shall be used to calculate the adjusted level of energy performance.
 - 2B. Weather.** The target level of energy performance is based on long-term average weather for the nearest standard weather station to the project site for which weather files are available. If local weather data are not available, weather shall be measured at the building and the measured values shall be used to calculate the adjusted levels of energy performance.
 - 2C. Schedules of Operation.** The target level of energy performance is based on estimates of thermostat settings, outside air ventilation rates, HVAC and lighting operating schedules. These assumptions shall be verified through the energy management system or stand-alone dataloggers and adjustments shall be made to the energy performance levels, if necessary.
 - 2D. Utility Rates.** The target level of energy performance is based on current utility rates for electricity and natural gas. The rates in effect during the second year of building operation shall be used to calculate the final energy performance levels.

Section 2. Computer Modeling

The following paragraphs are optional:

- 2E.** *Hot Water Use.* The target level of energy performance is based on estimates of the peak and hourly hot water use. These assumptions shall be verified through the energy management system or stand-alone dataloggers and adjustments shall be made to the energy performance levels.
- 2F.** *Surplus Space.* The target level of energy performance is based on an estimate of surplus and unconditional space for the building test period. The adjusted performance levels shall be based on actual surplus and unconditional space.
- 2G.** *Special Uses.* The target level of energy performance is based on an estimate of the percentage of special use areas in the building such as computer and copy centers. The adjusted performance levels shall be based on actual special uses, either additional spaces or different operation patterns.

Corrective Action

When To Use

All performance contracts (except tenant space improvement agreements) should contain this section on corrective action.

Contract

This section requires the Performance Contractor to make sure the design is successfully carried out during construction.

- 3. Corrective Action.** If the building fails to meet the target level of performance during the first or second years of building operation, the Performance Contractor, through the general contractor and warranties, will correct the problem by modifying the control systems, replacing malfunctioning equipment, or taking other corrective actions.

Commissioning

When To Use

Commissioning is a critical part of any energy efficiency effort. This section should be included with all energy performance contracts except tenant space improvements.

Contract

The data gathered as part of setting up measurement and evaluation equipment may be useful for commissioning. For instance, the commissioning team may want to see a profile of electric demand for a chiller during startup to help tune the cooling system. As a result, the time resolution of recorded data for the first occupied year may be chosen by the commissioning team; but the intervals should be no greater than 15 minutes.

4. Energy Commissioning. The building and its systems must be properly commissioned. The purpose of commissioning is to insure that systems are operating according to their design intent and that they are providing proper indoor air quality, comfort and energy efficiency. The commissioning process will result in a properly functioning facility, properly trained operation staff and documentation that describes system design intent and commissioning procedures.

4A. The Performance Contractor shall submit a commissioning plan as required below. The commissioning plan shall identify a commissioning agent to be responsible for oversight of the commissioning process, and shall identify commissioning team members who will perform testing and prepare documentation. The commissioning agent may be the Performance Contractor or another expert hired by the Performance Contractor.

The list of building systems covered in the commissioning plan in Paragraph 4B must be customized for each project. The following is a sample list.

4B. The building systems to be covered by the commissioning plan include: HVAC, lighting, energy management system, optical devices for daylighting, adjustable shades and other equipment important to the energy performance of the building.

4C. The plan will describe commissioning activities for the following project phases: proposal, design, construction, acceptance, post-acceptance.

4D. The deliverables produced during the commissioning process shall include, but not be limited to

1. Commissioning plan (design phase)
2. Design intent documentation (design phase)

Section 4. Commissioning

3. Commissioning static and functional test plans (design phase)
4. Final commissioning report (acceptance phase)
5. Verified as-built drawings (acceptance phase)
6. Operating and maintenance documents (acceptance phase)

4E. The procedure in the commissioning process shall be consistent with those in the following references or with other applicable standards.

1. ASHRAE Guideline 1-1996, The HVAC Commissioning Process
2. International Performance Measurement and Verification Protocol, Department of Energy, 1997.
3. BPA Measurement and Verification Protocol.

Measurement & Verification Contractor Responsibilities

When To Use

Measurement and verification plays a critical part in energy performance contracting. The actual energy performance of systems is measured to determine whether or not the performance target was achieved. This section must be included in all energy performance contracts.

Contract

5. **M&V Contractor.** The Owner will hire a measurement and verification (M&V) contractor, with the approval of the Performance Contractor. The M&V contractor will have the following responsibilities:

The following list of M&V contractor responsibilities is not intended to be comprehensive. Rather, it should serve as a minimum. Although, the quarterly reports to be written by the M&V contractor described in Paragraph 5C can be altered to meet the specific needs of the project. For instance, because of the speed with which systems are installed and commissioned in some fast-track projects, reports can be scheduled to coincide with specific project events.

- 5A. Participate in the commissioning process to make sure that the sensors, actuators and data collection mechanisms needed for building measurement and evaluation are in place and functioning properly.
- 5B. Review and monitor the stream of performance data produced by the building EMS once the building is operated.
- 5C. Produce quarterly reports during the first two years of building operation that:
 - 5C-1. Identify any problems with the data collection system and recommend corrective action for the general contractor (or controls contractor). It is expected that the warranty period for energy management systems will extend at least through two years.
 - 5C-2. Compare the actual energy performance to the base and/or target levels of performance. In the event that the building fails to meet the target level of performance, identify problem areas and make recommendations on how to improve performance.
 - 5C-3. Calculate the adjusted base and target levels of energy performance based on building measurements, using the procedures described in Section 2.

Measurement & Verification Performance Requirements

To ensure the availability of useful verification data, the M&V contractor should also have a contractual performance requirement. The following language is intended to be used for that purpose.

This section describes the control points of a comprehensive energy management system. The control points include standard ones required by an energy management system to perform common control functions as well as those required to calibrate a computer simulation model. Depending on the recommended efficiency measures, more points may be needed, or some may be discarded.

- 6. Measurement & Verification.** The Measurement & Verification system shall be used to determine if the target building performance is satisfied and provide feedback for target adjustments. The specified building performance data may be collected using either a stand-alone system, a building energy management system (EMS) or a combination of both.
 - 6A. Data Retrieval & Access.** The data acquisition system shall have the number of channels required to store output data. Installed equipment will include (List req'd equipment) . Software and hardware, as listed below, will be included.
 - a. Data storage/acquisition software
 - b. Communications software
 - c. Computer with appropriate system software and storage capacity
 - d. Uninterruptable Power Supply (UPS) or any appropriate battery backup system
 - e. Other _____
 - 6B. Data Acquisition & Storage.** The data acquisition system shall be configured to take readings at ___minute intervals for a period not less than 12 months. The accumulated data shall be permanently stored.
 - 6C. Measurements Points.** There shall be sufficient measurement channels to store the data from the following measurement points:
 - 6C-1. Weather Conditions.** If possible, on-site weather conditions shall be obtained from a local weather monitoring station. Otherwise, weather will be monitored at the building site. The final format of collected data shall be a weather file compatible for use with the computer simulation. The following variables shall be collected:
 - a. Drybulb temperature
 - b. Relative humidity

Section 6. Measurement and Verification Performance Requirements

- c. Global horizontal solar radiation
- d. Atmospheric pressure
- e. Wind direction
- f. Wind speed

6C-2. Temperature. Temperature sensors shall be installed in a representative sample of spaces. Temperature sensors shall be installed for each domestic hot water (DHW) system. The HVAC system type determines the number of process sensors. Temperature sensors may be of any type that provide an accuracy of $\pm 0.2^{\circ}\text{C}$. Wetted probes must be used for all fluid measurements.

- a. *Inside Air Temperature.* The indoor air temperature shall be measured at a sufficient number of locations to constitute a representative sample of space types, orientations, and occupancy.
- b. *Domestic Hot Water Temperature.* The domestic hot water temperature measurement shall be located downstream of the main circulation pump in the main feeder pipe.
- c. *HVAC Process Temperature.* Process temperatures of HVAC systems shall include both fluid and/or air distribution temperature sensing. The recommendations in the North American Energy Measurement and Verification Protocol shall be followed for locations of measurement probes.

6C-3. Electrical Loads. The number of electrical load measurement points is dependent on the electrical usage to be monitored. Each power measurement point has 2 output channels. AC Power Transducers (also referred to as W/Wh Transducers) with kW and kWh output are required. The kWh feature shall be a TTL (or equivalent device) type pulse counter that outputs the accumulated kWh use, at a resolution of 1 kWh per pulse. The kWh pulse count shall be converted to a kWh value. The output for storage shall be power factor corrected kW and kWh values. All measurements shall have an accuracy of $\pm 0.5\%$ full scale.

- a. *Space Conditioning.* Cooling and heating electrical loads are to be measured separately if the system allows. The minimum measurement points shall be a total cooling electrical load and a total heating electrical load.
 - a1. *Cooling.* For a central plant HVAC system, the total electrical load shall be measured on all the cooling pumps, fans, compressor and cooling tower. For monitoring packaged HVAC systems, the total electrical load of the cooling portion of all the units shall be measured.
 - a2. *Heating.* All the electrical loads associated with space heating shall be measured and stored.
- b. *Lighting Loads.* Applicable lighting load categories—such as halls and stairs, offices, retail—shall be separately measured. If available, lighting load data may be used to determine occupancy schedules. Exterior lighting and plug loads shall be measured. This includes all sign lighting and all unconditioned space lighting. These exterior loads do not need to be disaggregated.

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- c. *Total Building Load.* The total electrical load consumed by the building shall be measured and stored.

6C-4. Gas Sensors. Natural gas consumption shall be measured with electronic gas flow sensors. There shall be sufficient sensors to measure total gas consumption and DHW gas consumption. The sensors shall have a linearity of $\pm 3\%$ full scale and repeatability of $\pm 1\%$ full scale from 50% to 100% of rated maximum flow.

- a. *Total Consumption.* The total natural gas consumed by the building shall be measured.
- b. *Water Heating.* The natural gas consumed for production of domestic hot water shall be measured.

6C-5. Flow Measurements. The number of flow measurement points shall be determined by the necessity to measure DHW and/or HVAC process flows. All flow measurement sensors shall have an accuracy and linearity of $\pm 1\%$ of full range.

- a. *Hot Water Consumption Sensors.* The total amount of domestic hot water consumed in the building shall be measured. The number of domestic hot water sources will determine the number of sensors and their locations.
- b. *HVAC Process Flows.* HVAC process flows shall include fluid and/or air distribution where applicable.

RESOURCES

- AIA Document A201: General Conditions of the Contract for Construction*, 15th edition, American Institute of Architects, Washington DC, 1997. To order, call 202-626-7508, or contact your local AIA office.
- AIA Document B141: Standard Form of Agreement Between Owner and Architect*, 15th edition, American Institute of Architects, Washington DC, 1997. To order, call 202-626-7508, or contact your local AIA office.
- ASHRAE Guideline 1-1996: The HVAC Commissioning Process*, American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc., Atlanta, Georgia, 1996.
- BUSCH, JOHN and DIAMOND, RICHARD, *Does the "Feebate" Approach to A/E Compensation Lead to an Energy-Efficient Building?*, Proceedings of Building for the Future: Fourth National Energy-Efficient New Construction Conference, Vancouver B.C, 1996.
- CHONG, GORDON, DOUGHERTY, BETSY O., and HALLENBECK, HARRY C. (eds.), *Handbook on Project Delivery*, The American Institute of Architects, California Council, 1996. This is an immensely useful resource for learning about the various project delivery methods. It covers contract relationships, including responsibilities, financing, scheduling, and preferences of each party to the contract. To order, call 916-448-9082, or send email to AIACC@aol.com.
- ELEY, CHARLES, and PETERSON, ANN, *Models for New Building Performance Contracting*, TEEM '96, 1997.
- ELEY, CHARLES, PETERSON, ANN, and WENTWORTH, SCOTT, *New Building Energy Performance Contracting*, Third National Conference on New Construction Programs for Demand-Side Management Proceedings, Boston, Massachusetts, March, 1995.
- ELEY, CHARLES, and SYPHERS, GEOFFREY, *Performance Contracting for New Construction-Insuring Value From Your Investment*, Miami AIA Conference Proceedings, 1997.
- HUBBARD, GUNNAR, *Performance Based Fee Contracts: Doing It Right the First Time*, *Solar Today*, Jan/Feb 1997.
- HUBBARD, GUNNAR, and ELEY, CHARLES, *Green Fees: Getting Paid For Getting It Right - Performance Based Fee Contracts For New Construction*, *American Solar Energy Society Conference Proceedings*, Washington, DC, April 1997.
- KATS, GREG, HERRITY, KERRI, SCHILLER, STEVEN R., and MCGARAGHAN, SCOTT (eds.), *International Performance Measurement and Verification Protocol*, Version 2.0, U. S. Department of Energy 1997. DOE/EE-0081. No copyright. This resource has been extended to include new buildings as well as existing buildings. See especially Section 6.0. To order a paper copy, call 1-800-DOE-EREC, or visit the Energy Network homepage to download a free electronic copy from <http://www.eren.doe.gov>.
- LOVINS, AMORY B., *Energy-Efficient Buildings: Institutional Barriers and Opportunities*, E Source, Inc., 1994.
- PETERSON, ANN, and ELEY, CHARLES, *New Building Performance Contracting: Lessons Learned and New Ideas*, 1996 ACEEE Summer Study on Energy Efficiency of Buildings.
- SCHILLER, STEVEN R., and GUMERLOCK LEE, ANNE, *Performance Contracting - The Future for Energy Services and Market Transformation?*, Association of Energy Services Professionals 1997 Annual Conference.
- SWEET, JUSTIN, *Legal Aspects of Architecture Engineering and the Construction Process*, West Publishing, St. Paul, Minnesota, 1970.