Contracting for New Building Energy Efficiency

Charles Eley, Eley Associates, San Francisco, CA
Geoffrey Syphers, Xenergy, Oakland, CA
Jeff Ross Stein, Eley Associates, San Francisco, CA

ABSTRACT

This paper reports on recent experiments with new building energy performance contracting. Guidelines, supported by three case studies, are provided for the most common building delivery systems: design-build, plan specification and bid, and speculative. The guidelines address how to set and express the performance target, evaluate performance during the design process, measure performance after commissioning and construction, and structure compensation to provide monetary incentives for achieving the desired performance. The concept sets in place a free-market mechanism which will help overcome a general market failure in which profitable investments are not made because those who design and construct buildings typically have little or no incentive to aggressively pursue cost-effective energy efficiency opportunities.

The idea is not new for existing buildings. In fact, energy service companies have created an entire industry around borrowing from future energy savings to pay for energy efficient upgrades. With new buildings, the concept is similar. The crucial differences are that (1) the opportunities are greater because the owner has not already committed to particular building components or equipment, and (2) baseline and target energy amounts are derived from simulation modeling rather than past utility bills.

Introduction

When building owners and developers construct new buildings, they enter into professional services contracts with architects, engineers and construction managers. These contracts can contain clauses that specify a minimum level of energy efficiency for the building as a whole or for building systems, such as the mechanical or lighting systems. These so called "performance contracts" for new buildings have a parallel with performance contracts for existing buildings, where the cost of energy efficient improvements is financed through future energy savings.

In addition to the common criteria specified by the building owner, such as square feet and functionality, an additional energy efficiency requirement is included. In effect, the owner agrees to pay more if the building is energy efficient. By formalizing this agreement, a market-based mechanism is put into place to provide a positive incentive for design professionals and design/build contractors to *deliver* energy efficiency to the buyer or building owner. Professional agreements with performance clauses are in striking contrast to design fees that are either a percentage of the total construction budget or a flat rate. Such contracts have the effect of emphasizing speed and discouraging additional work that will result in energy efficiency.

Energy performance contracting is fundamentally a means of improving energy efficiency in new buildings. The owner who initiates a performance contract is seeking to provide an incentive to the A/E to design and help deliver an energy-efficient building. The investment in energy efficiency consists of additional professional services for design, energy analysis, building commissioning, and coordination between disciplines. The cost of the services is recovered through future energy savings.

New building performance contracting is different from retrofit work. While the basic intent is similar, new buildings pose problems that do not exist with retrofits. Chiefly, the building isn't built yet, so there is no obvious basecase 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 yield both a basecase and, after modeling a reasonable package of energy efficiency measures, a target level of energy performance.

Lighting, water heating, and space conditioning (heating, cooling, and ventilation) are the three energy end-uses that should be included in most energy performance contracts. Techniques for saving energy in these areas include lighting controls (occupancy or daylight sensors), low-e glazing, window overhangs, variable speed drives, and high efficiency mechanical equipment. Integrated design enables the extra cost of systems that reduce external and internal cooling loads to be offset by significantly downsizing space conditioning equipment. Furthermore, this can be done without increasing the designer's professional liability.

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 the patterns of operation. If they are significantly different from what was assumed in setting the target, then the target should be adjusted.

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.

Performance contracts should be included as part of the general agreement between the owner and the A/E or design-build firm. 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 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 (e.g., AIA Standard Agreement B141 rev. 1997.)

A simplified timeline for performance contracting is shown in Table 1.

Table 1. Performance Contracting Timeline

Project Phase	*Activities*
Pro Forma	Discussion
Programming	Set-up Performance Contract Hire A/E or Design-Build Firm
Schematic Design	Computer Model Performance Check
Design Development	Computer Model Performance Check
Construction Document	Computer Model Performance Check First Payment to A/E (optional)
Construction Administration	Approve Product/Equipment Substitutions
Commissioning/Occupancy	Second Payment to A/E (optional)
Building Operation	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. Each energy performance contract must be tailored to the conditions of a specific project, but all performance contracts should have four basic elements:

1. A clearly stated target or performance goal.
2. A method to evaluate performance during the design process.
3. A protocol for measuring performance after the building is constructed, commissioned, and occupied.
4. 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 should be developed concurrently with the building program and before a contract is negotiated with the A/E or design-build firm.

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 basecase. However, when no empirical basecase exists, computer modeling is used to simulate one. Modeling can be performed by an advisor to the owner. The basecase model is based on minimum code compliance or standard practice if standard practice is clearly above the code. The target model is based on a reasonable package of energy efficiency measures as determined by the owner and the advisor. 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 weigh 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 or design-build team selected for the project must, of course, be willing to accept the responsibilities associated with the performance contract, including computer modeling and building commissioning, or hire a subcontractor who has this experience. 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. If the proposed design does not meet the target, the A/E should be required to improve the design until it meets the target.

Measurement and Verification

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, so with a little foresight, the cost of M&V can be reasonable. M&V can be provided through a building management system, through stand-alone instrumentation, or both.

While the entity responsible for M&V is typically hired by the owner, it 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 tenants move in and get settled, so the second year is recommended for performance verification and for calculating bonus fees or penalties.

In order to avoid controversy, the M&V entity should develop an M&V plan before or during the design process which is based on accepted standard practice. The International Performance Measurement and Verification Protocol published by the Department of Energy is an excellent resource for learning about M&V procedures, examples, and how to avoid typical problems (Kats 1997).

Incentives and Penalties

An incentive may be offered for success and a penalty for failure in meeting the performance target. The incentive can be viewed as the net present value of the energy savings over a fixed time period, usually in the range of five to ten 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.

Application to Specific Building Delivery Systems

The methods used for building delivery range from design-build teams and construction managers to owner-architect-contractor relationships to situations in which the tenants are responsible for space improvements. While the principles are the same, the contract relationships, the target, techniques for verifying performance, and appropriate incentive schemes may vary.

Design-Build

There are many variations of the design-build (DB) model, but in general, the building owner signs a contract with a DB 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 written specification.

Contract Relationships. Figure 1 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.

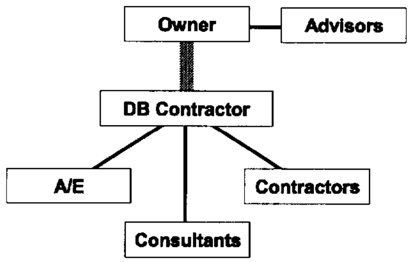

Figure 1. Design Build Model

Performance Target. For design-build projects, the performance target is best specified for the whole building and included in the contract between the owner and the DB. Usually, the target is determined from a computer model developed by an advisor to the owner and is based on the specification package plus any other energy measures that the owner and advisor decide are reasonable. Rather than choosing energy units like kWh or MBtu, it is better to express the target in dollars using predetermined utility rates. This gives the DB contractor the flexibility to achieve the required energy savings at the lowest life-cycle cost. Savings may come from cuts in electric or gas energy, electric demand reductions or load shifting, load prediction or control, but not from simply finding a better utility rate. Design-build teams have a high degree of control over the energy performance 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 estimates of energy use 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 adjust for 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 ahead of time. Because of the ease of accounting for 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 during the second year of operation. 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 typically heating, cooling, fans, hot water, and lighting. A typical split of energy end-uses for an office in a temperate climate is shown in Figure 2. About 54% of building energy use is considered in the performance contract. About 46% (equipment and elevators) is treated as a pass-through.

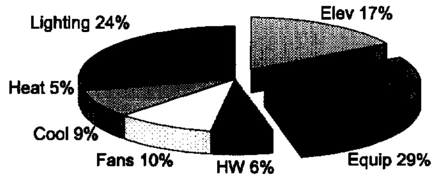

Figure 2. Energy End-Uses

Incentives. Penalties can be built into the contract for failure to meet the target and bonuses for doing better than the target. The recommended incentive structure for DB projects is shown in Figure 3. 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 or energy use is within a deadband which should be plus or minus about 15% of the included energy uses. If energy use is outside this deadband, then the owner compensates the DB for delivering a building that is better than that contracted for, or the DB compensates the owner for failing to meet the performance target. The amount of the bonus or penalty is shown in the diagram. Usually there is a maximum and minimum amount that is paid. The points on the curve are determined for each individual building.

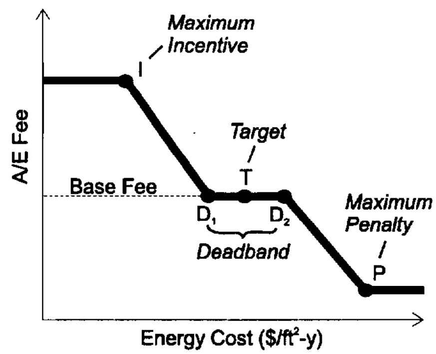

Figure 3. Performance Based Fee - Design/Build

Case Study. City Administration Buildings, Oakland. The city has a contract with a DB firm to design, engineer, construct, commission and deliver 450,000 square feet 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 $/ft^2 -y. The performance target ranges between $1.00 and $1.40/ft^2 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 ±$20,000, the target is considered met. If energy use is outside these bounds, the city is compensated or the DB rewarded, according to predetermined amounts up to a maximum penalty or reward of $250,000. The performance target was developed by an advisor to the city (Eley Associates) using DOE-2 and the building specification in the RFP submitted to DB firms. (The advisor's role in the Oakland buildings was funded by the California Energy Commission and the Energy Foundation.). The advisor also developed a specification for measurement and verification equipment. The performance target, reward/penalty system, and M&V specification were all included in the RFP.

The winning DB firm hired an energy consulting firm which modelled the proposed building at several milestones in the design process. The city's advisor verified that the building, as designed, met the target at these milestones. The DB also incorporated most of the M&V functions into the building-wide EMS.

Construction of the buildings is complete. Occupancy is scheduled to begin August 1, 1998. The city's advisor has been working with the DB subcontractors to insure that all M&V equipment is installed and functioning properly. During the first year of occupancy, the advisor, the DB subcontractors and the building operations staff will be using the M&V data to optimize building performance. During the second year, the advisor will use the M&V data to adjust the target for factors out of the DB's control (weather, occupancy schedules, etc) and to calculate the reward or penalty.

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.

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 is expanded to include a greater role in energy analysis, construction administration, and building commissioning.

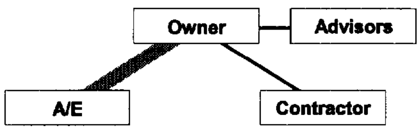

Figure 4. Plan and Specification Model

Performance Target. Two levels of energy performance are identified. The first (base) represents minimum compliance with applicable codes and standard practice, i.e. if standard practice is clearly above the code for a particular building component then this should be used in the basecase. 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 target is then converted and expressed as a percent reduction to the basecase. Depending on the stringency of the code used to define the basecase and other factors, performance targets represent a saving of 25% - 60% when compared with the basecase.

Design Evaluation. The A/E is responsible for estimating energy use and compliance with the target as the design of the building progresses. The timing and data requirements of these estimates should be specified in the agreement. Typically they would be provided at the conclusion of schematic design, design development and twice during contract documents. The estimates should be compared to the base and target levels of performance.

Measurement and Verification. Data from the second occupied year are used to verify the performance of the building. Based on monitored data, 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, 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. The recommended fee structure for "plan and spec" buildings is shown in Figure 5. An incentive or bonus fee is negotiated and awarded contingent on the building meeting the target level of performance. If performance falls between the base and target, then it is prorated.

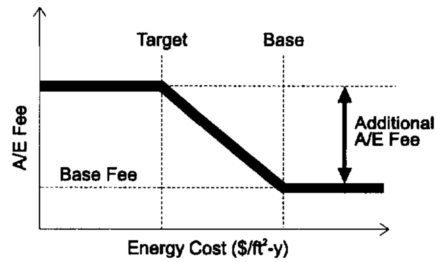

Figure 5. Performance Based Fee - Plan and Specification

There are at least three logical times when the additional fee can be distributed to the A/E: upon completion of design, upon completion of construction, and following measurement and verification. Most firms will want to see some compensation for their efforts before measurement and verification, but to retain the essential element of performance contracting, the final payment should be contingent on measured data of the occupied building. Table 2 is an example payment schedule. The breakdown of the A/E incentive into design, construction, and M&V payments depends on the degree of influence the owner expects the A/E to have in construction and commissioning and is a matter for negotiation.

Table 2. Sample Payment Schedule

At Completion of...	Estimated Incentive ($)	Percent Paid of Estimated Incentive	Dollars Paid ($)
Design	$500,000	20%	$100,000
Construction	$450,000	30%	$135,000
M&V	$300,000	50%	$150,000
Total	$1,250,000	100%	$385,000

Case Study. 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 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.

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 or others, if that is desired. From the owner's point of view, the performance contract is the same as design-build.

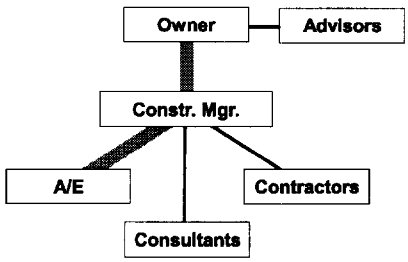

Figure 6. Construction Management Model

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.

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

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.

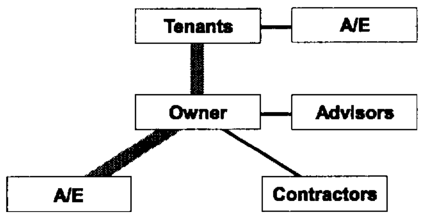

Figure 7. Speculative Building Model

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 terminal HVAC.

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 Figure 8.

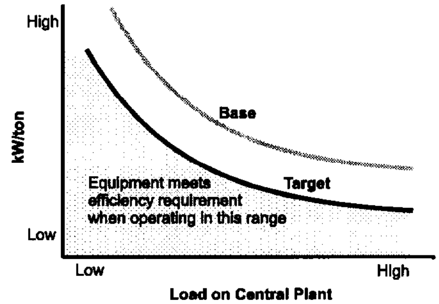

Figure 8. Performance Target for Central Plant

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.

Case Study. Four Times Square, New York, NY. Four Times Square is a 1.5 million-square-foot speculative, high-rise office building. 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.

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