

Advanced Simulation Guidebook

Volume II



energydesignresources

The High Performance
Building Process

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THE METHODS DESCRIBED IN
THIS GUIDEBOOK WILL
ENABLE ARCHITECTS AND
ENGINEERS TO USE ENERGY
MODELING MORE
EFFECTIVELY THROUGHOUT
THE ENTIRE DESIGN
PROCESS, AND PROPERLY
DOCUMENT THEIR RESULTS
FOR A VARIETY OF ENERGY
EFFICIENCY AND GREEN
BUILDING PROGRAMS.

This second volume of the Advanced Simulation Guidebook series is intended to teach readers about the high performance building process for commercial new construction. The goal of the high performance building process is to create buildings that meet owner and occupant needs in terms of energy efficiency, thermal comfort, and other sustainability areas—and do so in a way that reduces the necessary design effort and construction cost impact.

Commercial new construction projects in California have a long history of achieving exemplary energy efficiency, particularly when compared to the level of efficiency typical of projects in other parts of the United States. Since the introduction of California's Title 24 Standards in 1978, Golden State projects have been required to comply with one of the most stringent energy codes in the world. The performance requirements in Title 24 have been continually revised over the years as new energy technologies and design techniques have become available. The current Title 24 Standards require a high level of energy efficiency, and compliance with these standards is not a “given” without employing an integrated design process and efficient building systems.

Today, many projects are pursuing even higher levels of energy efficiency than what is required by Title 24 as a result of participation in utility-sponsored incentive programs, such as Savings By Design. Projects may also be seeking certification under the “Leadership in Energy and Environmental Design” (LEED) or the “Collaborative for High Performance Schools” (CHPS) green building rating/certification systems.

The first part of this guidebook addresses the high performance building process, and how energy modeling can be used to help project stakeholders make better informed design decisions. Specific ways that energy modeling can be used to support the high performance building process during each design phase are discussed. The second part of this guidebook addresses program-specific documentation requirements for Savings By Design, LEED for New Construction version 2.2. (LEED-NC-2.2), and California CHPS 2006 (CA-CHPS-2006).

There is a wealth of information on energy modeling, advanced building systems, and related topics available free-of-charge at the Energy Design Resources website (www.energydesignresources.com). A list of free resources that may be of interest is presented in the “For Additional Information” section at the end of this handbook.

THE HIGH PERFORMANCE BUILDING PROCESS

The fact that we are discussing the “high performance” building process implies that the typical way of creating buildings is “low performance”, but this is not the case. Rather, the traditional design and construction process has, for most buildings, been optimized to minimize the initial investment. The ‘trickle down’ effects of first cost minimization, aside from the obvious impact on building systems selection, include compression of the project schedule, reduced design fees, and reduction or elimination of quality assurance functions such as commissioning. This puts architects and engineers in a position where they have neither the time nor budget to design more innovative buildings. They are often discouraged from veering from tried-and-true design solutions. Given this, it is not surprising that many new buildings look a lot like each other.

ONE CHARACTERISTIC OF
THE HIGH PERFORMANCE
BUILDING PROCESS IS
ITS EMPHASIS ON
EARLY, ITERATIVE
ANALYSIS OF DESIGN
ALTERNATIVES.

The high performance building process, on the other hand, focuses on the life cycle costs of the building. The design decisions are driven by a combination of first cost sensitivity and also life cycle cost responsibility. One characteristic of the high performance building process is its emphasis on early, iterative analysis of design alternatives. In the earliest phases of design, trade-offs between different building features are analyzed to identify a solution that meets the owner’s needs. For example, the energy impact of installing skylights for 2% versus 4% of the total roof area might be analyzed to understand the trade-offs between reduced lighting requirements and increased building envelope heat gain. Building simulation programs analyze the interaction between building systems and therefore can play an important role in schematic design analysis and decision-making. The important thing is that the analysis is done early, before the design features under consideration have been incorporated into the project plans and specifications.

The benefits of early decision-making include the opportunity to reduce cost impacts and design effort (Figure 1). If design decisions are analyzed, accepted and incorporated early in the process then they can often have a significant impact with a correspondingly low level of effort (in terms of design time and/or construction cost). If changes are made late in the overall design process then their potential impact is often reduced while the effort to make the change is high.

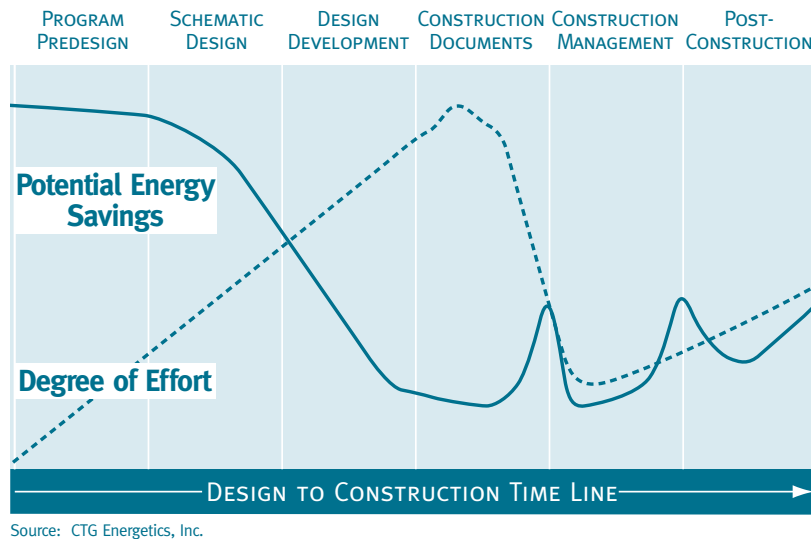


FIGURE 1: A HIGHER LEVEL OF ENERGY EFFICIENCY CAN BE ACHIEVED—AND AT A LOWER DEGREE OF EFFORT—WHEN ENERGY OPPORTUNITIES ARE CONSIDERED EARLY IN THE DESIGN PROCESS. AS THE DESIGN PROGRESSES IT BECOMES INCREASINGLY DIFFICULT TO IMPROVE ENERGY EFFICIENCY.

The traditional design and construction process is typically broken into the following phases:

Programming. The owner and architect collaboratively define the space requirements for the project, including space uses (e.g. office, break room, library), support spaces (lobby, restrooms, corridors) and the required area for each space based on projected occupancy. This establishes the required size of the building.

Schematic Design. Preliminary building massing and floor plans are developed based on programming requirements and site constraints. Preliminary HVAC system designs are developed, and space is allocated for the proposed equipment. Preliminary lighting design concepts are developed.

Design Development. Project designs are evaluated and documented in greater detail, based on programming requirements, the proposed massing and floor plans, and the anticipated project budget. Mechanical and electrical systems are sized and equipment locations are set.

Construction Documents. The project plans and specifications are developed with sufficient detail that they can be submitted to the local code authority for plan check. The plans are also usually distributed to contractors for bidding at this point.

Construction. A contractor is selected, who then builds the project according to the final set of construction documents.

Turn-Over/Occupancy. Once construction is complete, the building is turned over to the customer and the occupants move in.

IF DESIGN DECISIONS ARE ANALYZED, ACCEPTED AND INCORPORATED EARLY IN THE PROCESS THEN THEY CAN OFTEN HAVE A SIGNIFICANT IMPACT WITH A CORRESPONDINGLY LOW LEVEL OF EFFORT.

SUCCESSFUL PROJECTS

CONSIDER THE IMPACT OF
DESIGN DECISIONS ON ALL
PROJECT STAKEHOLDERS—
AND, GIVEN THE OFTENTIMES
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ESSENTIAL THAT DISCUSSION
OF ENERGY EFFICIENCY
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FORUM THAT KEEPS THE
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INFORMED.

While the design and construction phases might have different labels based on the project delivery format (e.g. design/build versus design/bid) the same general pattern is present in which an early conceptual design is developed based on the project requirements. This conceptual design is subsequently refined and detailed based on project requirements and constraints until it is sufficiently detailed that it can be constructed by a contractor.

There are many participants in the design and construction process, and they all wield some influence over the project design. Participants include the project owner/developer, various architects (design, landscape, interior design), various engineers (mechanical, electrical, civil, structural), a cost estimating consultant, the construction team (general contractor and their sub-contractors), and the local code authority. Project teams may also include a representative from the local utility, a sustainability consultant, an energy modeler, and a commissioning agent. Successful projects consider the impact of design decisions on all project stakeholders—and, given the oftentimes large project teams it is essential that discussion of energy efficiency features occurs in a forum that keeps the entire team engaged and informed. This is important because a design decision by one part of the design team—even if the decision seems minor—often has a major impact on the work of the other disciplines. For example, a decision by the architect to maximize use of daylight within a building to offset electrical lighting impacts every member of the team in some way:

- The owner, developer and cost consultant must evaluate and approve the cost impacts;
- The contractor must evaluate any constructability issues that the proposed changes might introduce;
- The architect must design the building envelope take advantage of daylight, including the quantity and location of windows, glazing performance properties, and use of fins, overhangs, light shelves and other features to control light introduction and distribution;
- The electrical engineer must incorporate appropriate light fixtures and controls to properly control the electric light system;
- The mechanical engineer must account for the quantity and type of glass in their heating and cooling load calculations;
- The structural engineer must consider the desired placement of glazing with respect to the location and size of structural members;
- The interior designer should select furniture, colors and finishes that do not excessively attenuate the incoming daylight;
- The sustainability consultant and energy modeler must consider the energy performance and indoor environmental quality impact;

The commissioning agent must eventually test the systems.

RATHER THAN GUESSING AT
THE IMPACT OF A PROPOSED
DESIGN CHANGE, ENERGY
MODELING CAN PROVIDE
USEFUL QUANTITATIVE
INFORMATION SUCH AS THE
ESTIMATED ANNUAL ENERGY
COST SAVINGS, IMPACT ON
TITLE 24 COMPLIANCE, AND
HOW THE CHANGE MIGHT
INFLUENCE ENERGY
EFFICIENCY INCENTIVES.

Given the potentially large number of design implications for any proposed energy efficiency feature, it is important to understand the owner's decision making process. When a design decision comes up, the owner must weigh a number of different issues:

- What is the cost?
- What energy cost savings might result?
- Does the proposed change improve the quality or function of the building?

For most projects, such decisions are primarily driven by the construction cost impact versus the anticipated cost savings over time. Rather than guessing at the impact of a proposed design change, energy modeling can provide useful quantitative information such as the estimated annual energy cost savings, impact on Title 24 compliance, and how the change might influence energy efficiency incentives (such as those offered by the Savings By Design program). However, in order for the energy model results to be useful they must be available at the right time in the project (before the design decisions have been made). This is one of the most important reasons to employ energy modeling in the earliest phases of design, when decisions are being made that can have profound impact on building energy use and comfort. This brings us to the central Catch-22 of energy modeling in commercial new construction, namely, the model is of greatest use during the early stages of design when the important decisions are made, but many modelers resist developing a model at this time because they think they don't have enough detailed design information.

The high performance building process begins in the earliest project phases, and continues after initial occupancy. Incorporating the owner's performance requirements into the project program helps to ensure that the design develops responsively to the owner's needs and expectations. After the building is constructed and occupied, there is a tremendous opportunity to learn about how certain design features performed in application so that the "lessons learned" can be applied to future projects. In between these two endpoints, the use of energy modeling can guide the decision-making process.

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USING SIMULATION TO GUIDE THE HIGH PERFORMANCE BUILDING PROCESS

Using building simulation as part of the high performance building process allows design team and owner to make informed decisions about energy efficiency. In this way, the energy efficiency features become an integral part of the project instead of an incremental add-on, which can reduce the cost of achieving higher levels of efficiency.

FOR PROJECTS THAT ARE
SEEKING INCENTIVES FROM
THE SAVINGS BY DESIGN
PROGRAM OR THAT ARE
SEEKING LEED FOR CHPS
CERTIFICATION, THE ENERGY
MODEL WILL BE THE
'YARDSTICK' BY WHICH
PROJECT ENERGY EFFICIENCY
IS MEASURED VERSUS EACH
PROGRAM'S MINIMUM
ENERGY PERFORMANCE
PREREQUISITE.

For projects that are seeking incentives from the Savings By Design program or that are seeking LEED for CHPS certification, the energy model will be the 'yardstick' by which project energy efficiency is measured versus each program's minimum energy performance prerequisite (10% better than 2005 Title 24 for Savings By Design and CHPS, 14% for LEED). Properly developed and employed, a single model can serve multiple purposes, including documenting Title 24 compliance, determining potential Savings by Design incentives for the owner and design team, and providing supporting documentation for multiple LEED or CHPS credits.

The most significant opportunity for improving building performance with energy modeling is to start early. Developing a basic energy model during the schematic design phase will allow the project team to evaluate basic design considerations such as the building form, orientation, and window configuration. As the design progresses through the design development and construction document phases, the energy model is refined and made more detailed to reflect the design decisions made along the way. As the model becomes more detailed it can be used to answer tougher, more detailed design questions, such as what kind of chiller will provide the best overall cooling system efficiency or which air handling unit will provide the lowest fan energy requirement.

The following sections describe how to apply building simulation during the schematic design, design development and construction document phases of a typical commercial new construction project.

Developing an Energy Model during Schematic Design

An energy model can be used during the schematic design phase to evaluate fundamental architectural issues, alternative building system concepts, and efficiency performance targets. The following types of questions can be evaluated during the schematic design phase, when only limited information is available for the project:

Building Form. What impact will different building forms (shapes) have on energy efficiency?

Building Orientation. What impact does building orientation have on heating loads, cooling loads, and overall energy use?

Envelope Construction. How do different wall and roof construction assemblies impact building heating and cooling loads? What energy savings will result from different levels of wall and roof insulation?

Glazing. How will the type, quantity, and placement of glazing impact building performance? What is the performance difference between single- and dual-pane windows? Can improving the glass performance result in a smaller capacity cooling system?

Heating, Ventilating, and Air Conditioning (HVAC) Systems. What are the relative performance differences between different HVAC system options, such as air-cooled packaged units versus a chilled water plant? What impact do different HVAC equipment offerings (e.g. standard versus high efficiency) have on energy cost and initial cost?

Performance Targets. If the project is pursuing a Savings By Design incentive or LEED/CHPS certification, do the schematic design concepts collectively provide the required level of energy performance? For example, what package of design features would be necessary for a project that plans to beat Title 24 requirements by 20%?

Developing energy performance criteria for different parts of the building design is one of the most useful modeling activities that can occur during the schematic design phase because such criteria establish the “roadmap” that the various members of the design team can follow to reach the overall project goals. Establishing performance criteria for different aspects of the building design (such as the lighting system) becomes increasingly important as project efficiency goals become more aggressive—a project that aspires to beat Title 24 requirements by 30 percent probably won’t reach their goal without detailed evaluation about how the proposed building will use energy and determination of the greatest opportunities for improved energy performance. The old adage “savings follows waste” definitely applies to whole building energy efficiency; knowing the largest energy uses (e.g. lighting, fans, cooling, heating) and which present the greatest opportunities for reduction makes it much easier to identify design solutions that have the greatest energy impact.

DEVELOPING ENERGY
PERFORMANCE CRITERIA FOR
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BUILDING DESIGN IS ONE OF
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DESIGN TEAM CAN FOLLOW
TO REACH THE OVERALL
PROJECT GOALS.

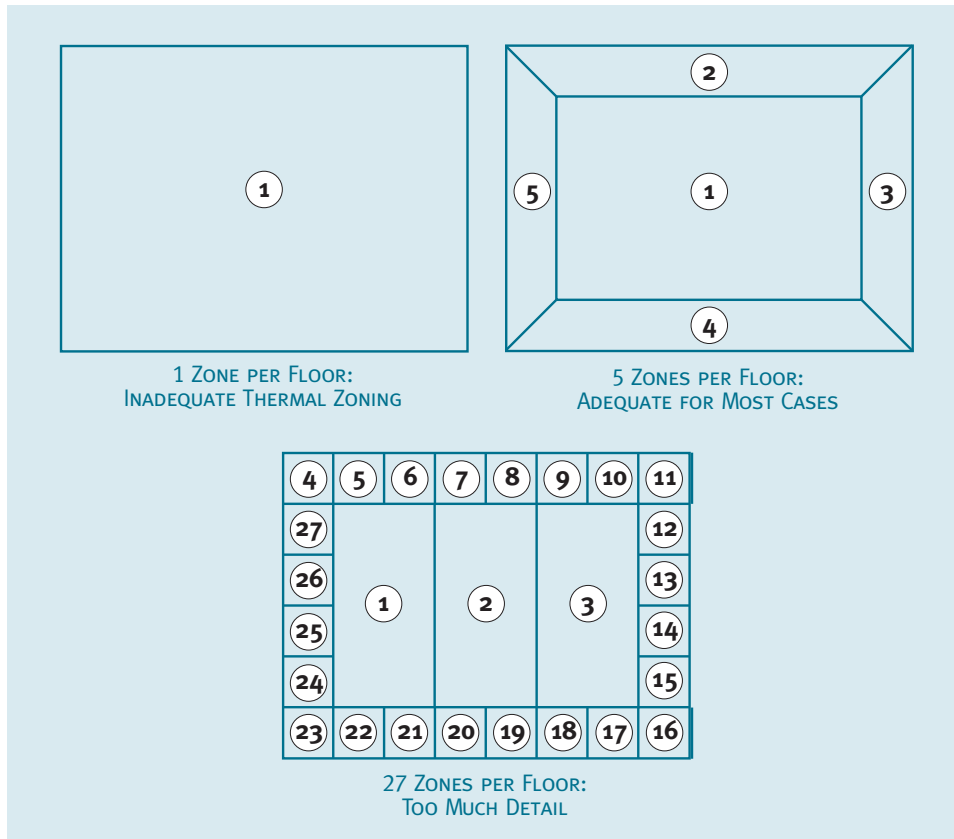
DESPITE THE FACT THAT
TITLE 24'S LIGHTING
EFFICIENCY REQUIREMENTS
HAVE BEEN MADE MUCH
MORE STRINGENT OVER THE
LAST SEVERAL CODE
REVISIONS, THIS IS STILL AN
OPPORTUNITY TO GO WELL
BEYOND THESE
REQUIREMENTS IN TERMS OF
EFFICIENCY—AND, A HIGHLY
EFFICIENT LIGHTING DESIGN
CAN GO A LONG WAY
TOWARDS MEETING AN
OVERALL BUILDING ENERGY
USE REDUCTION GOAL
BECAUSE INTERIOR LIGHTING
IS USUALLY THE LARGEST
SINGLE ENERGY END-USE IN
A COMMERCIAL BUILDING.

An energy efficiency opportunity that almost always plays a major role in achieving high levels of performance is the interior lighting system. One of the main reasons for this relates to the role that interior lighting plays in overall building energy use and Title 24 compliance. Despite the fact that Title 24's lighting efficiency requirements have been made much more stringent over the last several code revisions, this is still an opportunity to go well beyond these requirements in terms of efficiency—and, a highly efficient lighting design can go a long way towards meeting an overall building energy use reduction goal because interior lighting is usually the largest single energy end-use in a commercial building. For example, consider a proposed office building that is allowed 1.1 W/SF of interior lighting power by current Title 24 requirements and where lighting has been shown to represent about 30 percent of total building energy use based on preliminary modeling. If the as-designed lighting system can beat the Title 24 requirement by 33% then there will be an improvement in the whole building Title 24 performance of more than 10 percent. While it might seem like the overall energy use reduction should be 10 percent (e.g. lighting would use 20% instead of 30% of total building energy use), in fact it will be larger because the reduced internal heat gain from the lighting system leads to a corresponding reduction in cooling system capacity necessary to extract this heat from the building. A simple energy model developed during the schematic design phase can help quantify the level of efficiency for the lighting system that will be required to meet the overall efficiency goal because the energy model excels at quantifying the interactions between building systems. This lighting performance requirement can be provided to the lighting designer so their proposed design is developed appropriately during the more detailed project phases.

It is difficult to achieve a high level of whole building energy efficiency without an efficient interior lighting system, and therefore setting a lighting power performance criteria is perhaps the most significant outcome of the schematic design energy modeling process. Many projects have been able to meet their minimum level of energy performance for LEED or CHPS based almost entirely on the efficiency of the lighting system. Conversely, projects that include many advanced energy design features but that have a minimally code-compliant lighting system frequently do not meet their minimum performance thresholds.

Schematic Design Energy Modeling Tips and Tricks

Thermal Zoning. It is often the case that the thermal zoning approach will need to be considerably simplified during the schematic design phase because the floor plans have not yet been finalized. Unless the floor plans are finalized, resist the temptation to develop a highly detailed zoning strategy for your schematic design model—changing the zoning of an existing model is almost as much work as creating a new model. Usually, breaking the proposed building into its major functional areas (e.g. lobby, office, and core/support spaces) is the most reasonable strategy. For large spaces that are adjacent to an exterior wall, divide the space into 15-foot-deep zones along each exterior wall (to account for the heat gain from walls and glass) and assign the balance of the space to one or more interior zones (Figure 2).



Source: CTG Energetics, Inc.

Dealing with Yet-To-Be Determined Design Details. One of the reasons schematic design models aren't often employed is the lack of detailed information available about different building systems in the early phases of design. For example, the glass properties might not yet be finalized or the HVAC system type has not yet established. In such cases it is usually prudent to assume a Title 24 Prescriptive value for any building design details that aren't established yet. The most important thing is to keep all of the assumptions consistent in different model iterations so as to isolate the performance impact of the energy measure you are evaluating. For example, if you are analyzing the energy impact of single- versus dual-pane glass for the architect and have assumed the HVAC system to be minimum Title 24 efficiency rooftop packaged units with gas heating and electric cooling, it is important to hold those HVAC system assumptions constant for each energy model run that uses a different kind of glass. Otherwise, the energy use impact of different HVAC assumptions will distort the impact of the glass performance properties that you are trying to evaluate.

FIGURE 2: CONSIDER THE MODEL ZONING OPTIONS FOR A TYPICAL FLOOR OF A HIGH-RISE OFFICE TOWER DURING SCHEMATIC DESIGN. THE TOP FIGURE, WITH THE ENTIRE FLOOR TREATED AS ONE ZONE, DOES NOT ACCOUNT FOR THE UNIQUE THERMAL CHARACTERISTICS OF EXTERNAL SPACES ON EACH SIDE OF THE BUILDING AND THE BUILDING INTERIOR AREA. THE BOTTOM FIGURE, WHERE THE PERIMETER IS DIVIDED INTO SMALL 15' X 15' ZONES TO REPRESENT PRIVATE OFFICES, IS TOO DETAILED BECAUSE THERMALLY-SIMILAR ZONES CAN BE COMBINED TO SIMPLIFY THE MODEL WITHOUT REDUCING ACCURACY IN MOST CASES. THE MIDDLE FIGURE, WITH EACH EXTERIOR EXPOSURE GIVEN ITS OWN 15' DEEP ZONE AND WITH THE INTERIOR SPACE ALL DEFINED AS ONE ZONE, PROVIDES AN APPROPRIATE BALANCE OF MODEL ACCURACY AND DATA INPUT EFFICIENCY.

Read the Title 24 Standards and ACM Manual to Learn the Specific Baseline Requirements for Your Project. Sometimes, the specific requirements that Title 24 stipulates for certain building and system sizes present an opportunity to significantly improve energy efficiency. For example, a one- or two-story high school can show significant improvement in Title 24 performance with a well designed central chiller plant because the baseline system stipulated by the Alternative Calculation Method (ACM) Manual requirements is air-cooled rooftop packaged HVAC units. A recent high school project in Los Angeles boosted its Title 24 compliance margin by about 10 percent by virtue of the fact that a variable-speed chiller plant with variable-air-volume air distribution was employed instead of the baseline constant-volume packaged unit system type. Another example is a kindergarten center in San Diego that included air-side economizers of the cooling units even though they were not required by the Title 24 Standards for HVAC units of that particular size. The mild San Diego climate provides favorable conditions for economizers and other “free cooling” systems and this project achieved (along with other energy efficiency features) an improvement of more than 30 percent versus Title 24 requirements (Figure 3).

FIGURE 3: STANDARD DESIGN SYSTEM SELECTION FLOWCHART. THIS TABLE (WHICH APPEARS AS TABLE N2-10 IN THE 2005 NONRESIDENTIAL ACM MANUAL) SHOWS WHAT TYPE OF HVAC SYSTEM IS USED FOR THE STANDARD (BASELINE) BUILDING FOR PERFORMANCE-BASED TITLE 24 COMPLIANCE CALCULATIONS. FURTHER INFORMATION ABOUT EACH SYSTEM TYPE AND ITS UNDERLYING DESIGN ASSUMPTIONS CAN BE FOUND IN THE 2005 ACM MANUAL.

BUILDING TYPE	SYSTEM TYPE	PROPOSED DESIGN HEATING SOURCE	SYSTEM
LOW-RISE NONRESIDENTIAL	SINGLE ZONE	FOSSIL	PACKAGED SINGLE ZONE, GAS/ELECTRIC (SYSTEM 1)
		ELECTRIC	PACKAGED SINGLE ZONE, HEAT PUMP (SYSTEM 2)
	MULTIPLE ZONE	ANY	PACKAGED VAV, GAS BOILER WITH REHEAT (SYSTEM 3)
HIGH-RISE NONRESIDENTIAL	SINGLE ZONE	ANY	FOUR PIPE FAN COIL SYSTEM WITH CENTRAL PLANT (SYSTEM 5)
	MULTIPLE ZONE	ANY	CENTRAL VAV, GAS BOILER WITH REHEAT (SYSTEM 4)
RESIDENTIAL & HOTEL/MOTEL GUEST ROOM	HYDRONIC	ANY	FOUR PIPE FAN COIL SYSTEM WITH CENTRAL PLANT (SYSTEM 5)
	OTHER	FOSSIL	PACKAGED SINGLE ZONE, GAS/ELECTRIC, NO ECONOMIZER (SYSTEM 1)
		ELECTRIC	PACKAGED SINGLE ZONE, HEAT PUMP, NO ECONOMIZER (SYSTEM 2)

Source: 2005 Nonresidential ACM Manual

Combine the Promising Energy Measures to Determine the Interactive Effects. After individual energy efficiency measures have been evaluated, combine the most promising measures into a single building run in order to determine the overall, interactive effect on energy use and energy cost. The interactive result is usually different than the sum of the individual results for each energy efficiency measure. Also, look for combinations of measures that perform synergistically. For example, high performance glass and daylight dimming controls might provide reasonable efficiency gains when evaluated individually,

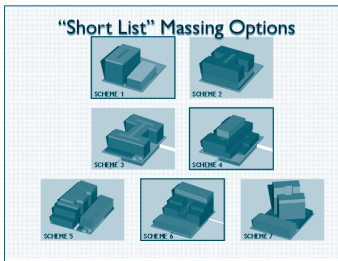
but have a much higher level of improvement when modeled together due to the increased daylight availability offered by the higher visible light transmittance (VLT) of the glass and the reduced requirement for supplemental electric lighting that results.

Timing is Everything. While it is always desirable to do the best energy modeling possible with the available information, this is sometimes not possible due to the timing of the owner's decision making process. With this in mind, it is usually better to provide a preliminary result based on a simplified energy model instead of waiting for a very detailed modeling effort to be completed—the detailed model results are not very useful if the owner has already made their decision. Part of the skill of applying simplified simulations during schematic design is understanding the implications of your modeling assumptions, and knowing what impacts the results most significantly. Many experienced modelers know that the difference in results between a model with simplified thermal zoning and a model using very detailed zoning is not usually that significant. On the other hand, the fact that the model is schematic does not excuse the modeler from being diligent accurate in fundamental ways. For example, not accurately defining the expected orientation of the building can lead to erroneous results for heating and cooling energy use. At the minimum, a schematic energy model should use appropriate climate data and account for the expected size, shape, orientation and usage of the proposed building.

Document Your Findings and the Resulting Action Items. While those who spend a lot of time working with energy models might find the results to be self-explanatory and simple to comprehend, it is important to remember that not everybody is a simulation guru. With this in mind, it is a good idea to summarize your results and recommendations in a brief report that is written at the right level of detail for your intended audience. If you are submitting results to the mechanical engineer then it may be appropriate to discuss detailed input assumptions and modeling methodology. On the other hand, if you are presenting results to the owner then it may be more appropriate to emphasize high-level results such as energy cost savings, Title 24 compliance margin, estimated Savings By Design incentives, and potential LEED or CHPS points. The important thing is to understand your audience and tailor your delivery accordingly.

IT IS USUALLY BETTER TO
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EFFORT TO BE COMPLETED—THE
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HAS ALREADY MADE THEIR
DECISION.

CASE STUDY: Caltrans District 7 Headquarters



SOURCE: AC MARTIN PARTNERS

Early schematic design-phase modeling can be used to improve the energy performance of the building envelope, even when very few details of the building systems design are known. For the Caltrans District 7 Headquarters in downtown Los Angeles, the design team initially generated 20 different massing schemes for the building. After reviewing the options with the client, the list was then refined to a “short list” of seven schemes. The design team then used building simulation to determine if any of the seven short-list schemes was inherently more energy efficient than the others.

Because the project was in the earliest phases of design, no specific design information had been developed for the mechanical and electrical systems. In addition, the construction properties of the exterior walls, roof, and glass were not yet determined. For the purposes of this early modeling effort, all seven schemes employed the same model assumptions. For the most part, all systems were assumed to meet minimum Title 24 prescriptive requirements. While it was understood that the building systems would eventually be designed to be highly efficient, using a consistent set of assumptions enabled the analysis to emphasize the difference in energy performance resulting from the building form and orientation.

SCHEME #	SITE ENERGY (MBTU/YR)	SOURCE ENERGY (MBTU/YR)	ENERGY COST (\$/YR)	ENERGY PERFORMANCE VS. SCHEME 1
1	67,561	143,030	\$1,391,450	0%
2	65,313	139,983	\$1,362,530	-2%
3	68,200	145,040	\$1,408,277	1%
4	66,034	140,617	\$1,369,789	-2%
5	64,325	137,942	\$1,345,509	-3%
6	61,592	133,851	\$1,310,395	-6%
7	65,120	139,548	\$1,360,634	-2%

SOURCE: CTG ENERGETICS, INC.

Each building scheme was modeled using the same weather file and utility rate assumptions. The preliminary analysis concluded that Scheme 6 would have annual energy costs that were six percent better than Scheme 1 (the baseline design). This early simulation allowed the design team and owner to make a better informed decision about the building envelope that would best meet their needs.

Refining the Model during Design Development

The amount of work necessary to revise the energy model during design develop depends on how much of the design information has significantly changed since the schematic design phase. If the schematic design model's thermal zoning is still accurate then it is usually most time-efficient to update the existing schematic design model to reflect the current state of design for the various building systems. On the other hand, if the schematic design energy model was very preliminary or if much about the building form has changed then it will likely be faster to start a new model.

The goal of the design development modeling work is to create a model that accurately reflects the current design, and that will be readily updated during the construction document and/or submittal stage of the project. If the design development model is developed accurately then future model revisions will likely be limited to revising the performance parameters for specific pieces of equipment (e.g. chiller efficiency, fan power) rather than making changes to the building envelope.

IF THE DESIGN DEVELOPMENT
MODEL IS DEVELOPED
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REVISIONS WILL LIKELY BE
LIMITED TO REVISING THE
PERFORMANCE PARAMETERS FOR
SPECIFIC PIECES OF EQUIPMENT.

Design Development Energy Modeling Tips and Tricks

Thermal Zoning Should Be Accurate. The thermal zoning for the design development energy model should accurately reflect the actual zoning of the as-designed HVAC systems. The quantity, capacity, and zone assignments of the HVAC systems should match what is shown on the mechanical system design drawings. It is important to differentiate between 'accurate' thermal zoning and 'identical' thermal zoning. The goal is to create an accurate zoning plan that mimics the loads that will actually be seen by each HVAC system; there are situations where zoning can be simplified with little impact on the quality of model results. The most common opportunity for simplifying the thermal zoning would be when there are a large number of comparable HVAC units serving similar spaces (e.g. water source heat pumps or split systems serving identical offices on the same side of the building). In such circumstances it is acceptable to use multipliers for the systems and treat the individual zones as a larger single zone. The logic that should be applied in such situations is that the zones can be combined if they have similar thermal loads (e.g. are adjacent offices along the same exterior orientation of the building), similar space usages, and similar schedules of operation. The zoning should also reflect the inclusion of any special control strategies that will be implemented. For example, a conference room that will have demand-controlled ventilation capabilities should be zoned separately from adjoining, non-DCV spaces. Interior zones can be consolidated based on the systems that serve them as well as the actual space usage. In general, interior zones tend to be larger than exterior zones.

ZONES CAN BE COMBINED IF
THEY HAVE SIMILAR
THERMAL LOADS (E.G. ARE
ADJACENT OFFICES ALONG
THE SAME EXTERIOR
ORIENTATION OF THE
BUILDING), SIMILAR SPACE
USAGES, AND SIMILAR
SCHEDULES OF OPERATION.

Confirm that the Current Design Incorporates Required Energy Performance

Criteria. Sometimes the energy efficiency performance criteria established during schematic design are forgotten or distorted during the design development phase. With this in mind, it is important to evaluate the design development plans and specifications with an eye towards verifying these performance criteria. For example, if the lighting designer agreed to design the interior lighting system at 0.85 W/SF but the design development package shows a system that is closer to 1.1 W/SF then it would be important to draw attention to this deviation since it will reduce the level of energy performance for the project. Another aspect of the building design that is not always pinned down at an early stage is the performance properties for the glass. If the architect has not selected a glazing assembly and provided the appropriate documentation of the performance then the HVAC engineer usually has to assume a “worst case” for the glass when they develop their cooling and heating load calculations. Accordingly, if the glass selection can be finalized (including the window configuration, framing details, solar heat gain coefficient, visible transmittance, u-value, and industry ratings like NFRC 100 and 200) then the HVAC systems can be “right-sized” instead of “super-sized”.

Compare Calculated Versus Actual HVAC System Capacities. Sometimes it is the case that HVAC systems are oversized by the designer, which increases energy use and first cost in most cases. There are a variety of reasons that this can occur, including application of “rule-of-thumb” engineer or lack of information about the actual internal and external thermal loads. At other times, the HVAC designer has future facility requirements in mind that the energy modeler is not aware of. It is worthwhile to discuss it with the HVAC designer whenever there is a large discrepancy between calculated loads and actual equipment capacity.

Be On the Lookout for Budget-Driven Design Changes. Sometimes, the anticipated cost for a project goes over budget, which leads to evaluation of value engineering options. From an energy modeling perspective, the responsibility is to be aware when such changes are proposed so they can be modeled, as well as notifying the project team promptly if a seemingly minor value engineering decision might have significant energy efficiency consequences.

Finalizing the Model During Construction Documents and Bidding

If the design development model was done well, then the model refinements made during the construction documents and bidding phases should just consist of final check of properties for various building components. This is the point in time when the energy model is finalized and submitted for a variety of documentation activities (CHPS, LEED, Savings BY Design, Title 24 Compliance).

Construction Document and Bidding Phase Energy Modeling Tips and Tricks

Check the Final Plans and Specifications for Changes That Impact Energy Efficiency.

Before finalizing the energy model, confirm that the following items are accurately reflected in the model:

- Glazing properties
- Light Power Density
- Lighting Controls
- HVAC Capacity and Efficiency
- Energy Saving Sequences of Operation

When equipment information is submitted for approval, double check these values again to make sure nothing has changed that would impact the energy model results. For example, if the specifications require that the windows be tested and labeled in accordance with NFRC 100 and 200 but the submitted project information does not include this then it should be brought to the project team's attention. Such a deviation would require that the unlabeled glass be modeled using CEC default values that tend to be conservative when compared to actual glass performance values. Also, pay particular attention to the HVAC submittals to ensure that equipment capacity, efficiency, and energy-savings features are included. For example, if the space heating boiler temperature is supposed to be reset based on outside air temperature in order to reduce reheat energy then it is important that the submitted boiler includes this (frequently) optional remote reset capability.

CASE STUDY: Coast Community College District Administrative Building



SOURCE: BUNDY-FINKEL ARCHITECTS

With proper planning, an energy model can be used to serve multiple purposes in a commercial new construction project. During the design of the new 60,000 SF Coast Community College District Administrative Building, the same model was used for establishing energy performance criteria for the design, evaluating the impact of an on-site photovoltaic system, and documenting several LEED-NC-2.2 credits and prerequisites.

Because the project was envisioned to take full advantage of natural light, the energy model was used initially to evaluate different glazing configurations and different levels of glass performance (single- versus dual-pane, different solar heat gain coefficients). The trade-offs between reduced lighting energy use and increased heat gain through the glass was able to be evaluated in an interactive manner. The model results enabled the design team to select glass that provides a balance of solar control and daylight performance. In addition, the early model results concluded that a highly efficient interior lighting system would provide a significant efficiency boost. As a result, a lighting power density performance target of 0.90 W/SF was established. Through a combination of efficient fixture selection and the use of advanced lighting controls, the project was able to significantly improve upon this performance target.

Because the district wanted to make their new building an example of green design for students and staff, they decided to include a photovoltaic (PV) system as part of the project. In order to provide adequate space for a large, properly oriented PV array, it was determined that the PV system would be mounted on top of shading structures for the parking lot. In addition to providing shading for cars, this also made the PV system a highly visible aspect of the building design. The energy model was used to predict the energy requirements for the building, and to determine how much of the electrical use would potentially be offset by the on-site energy system. Based on the model results, it was expected that the PV system would offset about 23 percent of total building electrical use.

The project had set an early goal for achieving a 'Silver' rating under LEED-NC-2.2. The energy model was used to support the documentation for several LEED credits and prerequisites, including: EAp2 (Minimum Energy Performance), EAc1 (Optimize Energy Performance), EAc2 (On-Site Renewable Energy), and IDc1 (Exemplary Performance for EAc2). In total, nine of the project's 36 attempted LEED points were documented using the energy model, showing that a commitment to energy efficiency along with smart use of energy modeling can provide a significant performance boost for projects pursuing LEED certification.

At this point, the energy model can serve as the documentation basis for one or more incentive or certification programs. The following sections discuss the documentation requirements for three different programs:

Savings By Design: A commercial new construction energy efficiency program that is administered by California's investor-owned utilities in their respective service territories;

LEED-NC-2.2: "Leadership in Energy and Environmental Design for New Construction, version 2.2", is a voluntary green building rating system that is administered by the U.S. Green Building Council;

CA-CHPS-2006: California Collaborative for High Performance Schools, 2006 Edition, also known as "CHPS" is a green building rating system that has been adapted for the particular needs of the K-12 schools market.

ENERGY MODELING APPROACH FOR SPECIFIC PROGRAMS

Savings By Design

Commercial new construction projects that participate in the Savings by Design program can earn financial incentives for achieving levels of energy efficiency that exceed code requirements. Savings By Design offers two ways to earn incentives. The “Systems Approach” is a menu-based format that is most appropriate for small projects. The “Whole Building Approach” typically provides higher incentive levels, and is targeted at projects achieving energy performance of at least 10 percent better than 2005 Title 24 requirements (based on current program requirements). While Savings By Design is periodically revised to reflect changes to Title 24, the Whole Building Approach typically maintains this structure of establishing incentives based on exceeding Title 24 by a certain percentage. As a result, an energy model is the logical way to document “whole building” energy performance.

The Savings By Design program determines incentives on a “Time-Dependent Valuation” (TDV) basis for energy use. The essence of the TDV concept is that energy use is assigned a different value based on when the energy is being used. Energy used on a summer weekday afternoon (when utility electrical demand tends to be highest) is assigned a higher value than energy used in the middle of the night (when utility electrical demand is lower). As a result, energy efficiency measures that reduce on-peak electrical demand (such as thermal energy storage or automatic daylight dimming controls) have a more significant impact on Title 24 performance than measures that do not.

From a building simulation standpoint, it is often the case that the same energy model used to demonstrate compliance with Title 24 under the Performance Rating Method is all that is required for documenting the Savings By Design incentive. In fact, some building simulation programs (EnergyPro, for example) can automatically generate the documentation that gets submitted to the utility.

FORM #	TITLE	INFORMATION
UTIL-1	UTILITY INCENTIVE WORKSHEET (OWNER)	PROVIDES COMPARISON BY END-USE OF ELECTRICITY AND GAS FOR STANDARD AND PROPOSED PROJECT. PRESENTS POTENTIAL OWNER INCENTIVE CALCULATION AND AMOUNT BASED ON CURRENT PROGRAM.
UTIL-DT	UTILITY INCENTIVE WORKSHEET (DESIGN TEAM)	PROVIDES COMPARISON BY END-USE OF ELECTRICITY AND GAS FOR STANDARD AND PROPOSED PROJECT. PRESENTS POTENTIAL OWNER INCENTIVE CALCULATION AND AMOUNT BASED ON CURRENT PROGRAM.
SCP-1	SUSTAINABLE COMMUNITIES PROGRAM INCENTIVE WORKSHEET (OWNER)	APPLICABLE ONLY FOR PROJECTS PARTICIPATING IN THE SUSTAINABLE COMMUNITIES PROGRAM. PROVIDES COMPARISON BY END-USE OF ELECTRICITY AND GAS FOR STANDARD AND PROPOSED PROJECT. PRESENTS POTENTIAL OWNER INCENTIVE CALCULATION AND AMOUNT BASED ON CURRENT PROGRAM.
SCP-2	SUSTAINABLE COMMUNITIES PROGRAM INCENTIVE WORKSHEET (DESIGN TEAM)	APPLICABLE ONLY FOR PROJECTS PARTICIPATING IN THE SUSTAINABLE COMMUNITIES PROGRAM. PROVIDES COMPARISON BY END-USE OF ELECTRICITY AND GAS FOR STANDARD AND PROPOSED PROJECT. PRESENTS POTENTIAL DESIGN TEAM INCENTIVE CALCULATION AND AMOUNT BASED ON CURRENT PROGRAM.
ECON-1	ENERGY USE AND COST SUMMARY	PROVIDES MONTHLY AND TOTAL COMPARISON BETWEEN STANDARD AND PROPOSED BUILDING FOR ELECTRICITY AND NATURAL GAS USE, AS WELL AS ENERGY COST.

FIGURE 4: SAVINGS BY DESIGN DOCUMENTATION FORMS

If a project is using EnergyPro for Title 24 compliance documentation, all that needs to be done is to click on the 'Report Wizard' button and then select the check boxes for each form requested by the utility. These forms will then be automatically generated the next time the simulation runs, appearing near the end of the Title 24 report.

If a project is using a simulation program other than EnergyPro for Title 24 compliance documentation then check the program documentation to determine if it can automatically generate the required Savings By Design forms. Because most simulation programs do not automatically report results using the TDV methodology, it may be the case that some simulation programs cannot generate the energy results needed to document the incentive. Be sure to check program documentation about this specific issue. Also, it makes sense to ask your utility representative if other projects have successfully completed their Savings By Design documentation using the program you might be considering.

A few things to keep in mind when working on Savings By Design projects:

TO ENSURE A SMOOTHER
PROJECT AND MAXIMIZE
INCENTIVES, IT IS A GOOD
IDEA TO CONTACT YOUR
LOCAL UTILITY SAVINGS BY
DESIGN REPRESENTATIVE
EARLY IN THE PROJECT TO
GET IT ON THEIR PROJECT
TRACKING “RADAR”.

Contact Your Utility Representative Early. To ensure a smoother project and maximize incentives, it is a good idea to contact your local utility Savings By Design representative early in the project to get it on their project tracking “radar”. They can let you know about incentive levels, program requirements, and perhaps even upcoming training or other events that can provide beneficial information. They may also have important information about program deadlines and funding levels.

Start Modeling Early. With proper planning, an energy model can be developed during schematic design as a tool for evaluating energy efficiency options, and then updated near the end of the construction document phase for both Title 24 compliance and Savings By Design incentive determination. Using the energy model as a decision-making tool during design development enables the design team to make better informed decisions about a variety of energy efficiency measures, which can lead to a more cost-effective project and potentially higher incentives.

Understand the Modeling Requirements. Sometimes, the way design teams share the burden of the Title 24 documentation for the building envelope, lighting, and mechanical systems, does not fully support the Savings By Design program requirements. The Savings By Design Whole Building Approach requires a Performance based Title 24 compliance approach that addresses the building envelope, mechanical, and lighting systems; prescriptive compliance documents might be acceptable for the building department but they are not adequate for the Whole Building Approach. It is common for the building envelope and mechanical system documentation to be included in a performance-based energy model, whereas the lighting system is documented using prescriptive compliance. One way to ensure a smooth Savings By Design submittal is to coordinate in advance so that all required design components are included in the energy model. Typically, this means that the final lighting design values (lighting power density or fixture/control inventory) need to be entered into each zone of the energy model. Some utilities expect the lighting inputs to be based on the quantity and type of fixtures and lighting controls in each zone, while others will accept a lighting power density value that accounts for the lighting power and any associated control credits. Be sure to ask your Savings By Design representative which method they prefer.

The Leadership in Environmental and Energy Design (LEED) rating system has become immensely popular in recent years as a way to measure the sustainability performance of a variety of building types. The new construction version of the rating system (LEED-NC) was updated from version 2.2 to version 3 in April 2009. While there are changes between the two versions in some areas of the rating system, the methodology for showing compliance with Energy and Atmosphere credit 1, “Optimize Energy Performance” remains unchanged. Thus, the following discussion¹ would be applicable to LEED for new construction projects registered under either the v2.2 or v3 versions. The most notable point to make in this regard for projects in California is that both v2.2 and v3 reference the 2005 edition of Title 24 as the energy code for determining baseline performance.

LEED-NC and California Title 24-2005

USGBC deems Title 24-2005 to be directly equivalent to ASHRAE 90.1-2004 for projects within the state of California. Projects within California may still elect to use ASHRAE 90.1-2004 instead of Title

24-2005. However, once the Title 24 or ASHRAE path is chosen, it must be used consistently.

This equivalency is for the purpose of certification of the following LEED-NC v2.2 credits:

- Minimum Energy Performance - EAp2
- Optimize Energy Performance - EAc1
- On-Site Renewable Energy –EAc2
- Green Power –EAc6

LEED credit will be awarded based on established LEED-NC v2.2 performance thresholds for EAc1, EAc2, and EAc6, as in the tables below. It should be noted that the LEED-NC-2.2 Reference Guide states that there are no Exemplary Performance points available for EA-c1, c2 and c6, but this is not the case. The table below identifies the levels needed to achieve ID credits.

THE NEW CONSTRUCTION VERSION OF THE RATING SYSTEM (LEED-NC) WAS UPDATED FROM VERSION 2.2 TO VERSION 3 IN APRIL 2009. WHILE THERE ARE CHANGES BETWEEN THE TWO VERSIONS IN SOME AREAS OF THE RATING SYSTEM, THE METHODOLOGY FOR SHOWING COMPLIANCE WITH ENERGY AND ATMOSPHERE CREDIT 1, “OPTIMIZE ENERGY PERFORMANCE” REMAINS UNCHANGED.

1 The following instructions for completing LEED documentation for California projects were developed by the U.S. Green Building Council and are posted on their website (www.usgbc.org). We have adapted the USGBC instructions in the following narrative.

FIGURE 5: 2005 TITLE 24

PERFORMANCE LEVELS AND
ASSOCIATED POINTS FOR
VARIOUS LEED CREDITS.

NOTE THAT LEED
PERFORMANCE IS BASED ON
ENERGY COST AND MUST
INCLUDE ALL ENERGY USES
ASSOCIATED WITH THE
BUILDING.

NEW CONSTRUCTION								
	EAp1		EAc1		EAc2		EAc6	
	90.1-2004	TITLE 24 2005	90.1-2004	TITLE 24 2005	90.1-2004	TITLE 24 2005	90.1-2004	TITLE 24 2005
PASS	YES	YES						
1 POINTS			10.5%	10.5%	2.5%	2.5%	35.0%	35.0%
2 POINTS			14.0%	14.0%	7.5%	7.5%	70.0%	70.0%
3 POINTS			17.5%	17.5%	12.0%	12.0%		
4 POINTS			21.0%	21.0%	17.5%	17.5%		
5 POINTS			24.5%	24.5%				
6 POINTS			28.0%	28.0%				
7 POINTS			31.5%	31.5%				
8 POINTS			35.0%	35.0%				
9 POINTS			38.5%	38.5%				
10 POINTS			42.0%	42.0%				
ID CREDIT			45.5%	45.5%				

EXISTING BUILDING WITH MAJOR RENOVATIONS								
	EAp1		EAc1		EAc2		EAc6	
	90.1-2004	TITLE 24 2005	90.1-2004	TITLE 24 2005	90.1-2004	TITLE 24 2005	90.1-2004	TITLE 24 2005
PASS	YES	YES						
1 POINTS			3.5%	3.5%	2.5%	2.5%	35.0%	35.0%
2 POINTS			7.0%	7.0%	7.5%	7.5%	70.0%	70.0%
3 POINTS			10.5%	10.5%	12.0%	12.0%		
4 POINTS			14.0%	14.0%	17.5%	17.5%		
5 POINTS			17.5%	17.5%				
6 POINTS			21.0%	21.0%				
7 POINTS			24.5%	24.5%				
8 POINTS			28.0%	28.0%				
9 POINTS			31.5%	31.5%				
10 POINTS			35.0%	35.0%				
ID CREDIT			38.5%	38.5%				

Source: U.S. Green Building Council

Instructions for completing LEED Documentation for EAc1

The documentation required for EAc1 is lengthy and detailed. The following concepts and instructions will assist in addressing the most common pitfalls encountered when submitting EAc1 documentation.

Energy Cost as the Basis for Calculations

Energy use (kBtu/sf-yr) must be converted to annual energy cost (\$/yr) in order to calculate LEED points. Projects may use either the energy rates referenced in the LEED Reference Guide, or actual rates may be entered into the Title 24 certified energy model.

To enter actual energy rates into EnergyPro, select the main building icon, then select the tab for each energy type (Fuel #1, Fuel #2, etc.), select the source fuel type, and select the utility rate that applies for your project, or enter a new utility rate based on utility tariffs. View the bottom of the ECON-1 report or the ES-D DOE-2 simulation output report to see the Virtual Rate.

Completing the EAc1 Template

A major component of the EAc1 template is Table 1.4, where the user is to document the standard and as-designed features of the building and its envelope, mechanical, and lighting components. To identify the Baseline building envelope inputs for Table 1.4, please reference the Title-24 2005 Building Energy Efficiency Standards, Table 143-A, B or C for all envelope inputs. Reference Title-24 2005 Building Energy Efficiency Standards, Tables 112-A through 112-M for equipment efficiencies. Reference the 2005 Non-Residential ACM Manual Table N2-10 for HVAC System Types and efficiencies.

To fill out section 1.8.1, complete only the Baseline 0 deg. rotation column with the Title-24 standard results from the UTIL-1 form, leaving the other columns (i.e. Baseline 90 deg., Baseline 270 deg., etc.) blank. Fill in the data for Energy Consumption only (energy demand is not required).

If the Standard Case virtual electric energy rate exceeds the Proposed Case virtual electric energy rate by more than 10%, you must complete the narrative at the end of the EAc1 template to describe the factors that impacted the virtual electric rate (i.e. thermal energy storage, low lighting power densities, etc. resulting in lower demand charges). The narrative must also reference the total peak electric demand for the standard versus the proposed case

as defined in the UTIL-1 EnergyPro report or the ES-E DOE-2 Simulation file report generated by EnergyPro or eQUEST.

Required EAc1 Backup Documentation

In addition to completing the EAc1 template, it is also necessary to upload backup documentation to LEED Online. Fortunately, the reports produced by EnergyPro and other State-approved building simulation programs provide most of the information that is required. The backup information typically consists of:

- Specific EnergyPro reports;
- Calculations for energy uses that are not included in the EnergyPro annual energy use calculations, such as exterior lighting, lighting in unconditioned spaces, and parking garage ventilation;
- Any Exceptional Calculation Method information needed to substantiate other energy savings calculations.

It is worthwhile to note that version 5 of EnergyPro (released in the second quarter of 2009) has an optional program module that provides a LEED EAc1 report that greatly simplifies completion of EAc1 documentation. Check the program website (www.energysoft.com) for further information.

EnergyPro Reports

Upload the PERF-1, UTIL-1, and ECON-1 reports as backup documentation. On the UTIL-1, Step 3 Annual Site Energy Use, identify the kWh and therms used for each energy component, and input this data in Table 1.8.1 (for the Title-24 Standard Case) and Table 1.8.2 (for the Proposed Case). From the EIA tables in the LEED Reference Guide, or calculated from the ECON-1 form, identify the energy cost per energy type (electricity and natural gas), and input this data in Table 1.8.1 and 1.8.2

Note: The UTIL-1 and ECON-1 reports may ONLY be used when the model is run in compliance mode. If the model is run in Non-Compliance mode, the baseline HVAC System type used may be inconsistent with Title-24 requirements, and the data will not match LEED modeling protocol. If the project is run in non-compliance mode, the user must provide a narrative with sufficient supporting documentation to verify that the budget case HVAC system type and parameters match the Title-24 ACM (Alternative Calculation Method) Manual requirements.

Reporting Process Energy in the EAc1 LEED Template

For process loads that cannot be modeled in the energy simulation software (such as garage ventilation, pool heating, etc.), calculate the energy consumption using a spreadsheet or other specialized simulation package. Calculate the energy cost for these end-uses using the virtual utility rates described above. Upload a summary of these calculations to LEED Online as backup documentation. Input the energy consumption as a separate end-use in the LEED EAc1 Template, Tables 1.8.1 and 1.8.2. Add the additional cost for these end-uses to the total energy cost, and include the combined costs in Tables 1.8.1b and 1.8.2b

Exterior and Unconditioned Space Lighting

All exterior and unconditioned space lighting shall be included in the energy calculations for EAc1. Title 24 provides lighting power allowances for two kinds of exterior lighting. The first is General Site Illuminance, per 2005 Building Energy Efficiency Standards (2005 BEES) Table 147-A. This is tradable within its own category, but is not tradable to any other energy use category. Credit may be taken for improved efficiency.

The second is for Specific Applications, as shown in 2005 BEES Table 147-B. This is a “use-it-or-lose-it” allowance for each individual application. Credit may not be taken for improved efficiency.

Reporting Exterior Lighting Energy in EAc1 LEED Template

The Standard exterior lighting hours of use and the Proposed Exterior lighting hours of use, shall be modeled identically in the budget and proposed case.

For EnergyPro for General Site Illumination (Table 147-A):

1. For the Standard exterior lighting, identify the Total Allotted Watts, as defined in OLTG-2-C, Part 1 of 4.
2. For the Proposed Exterior Lighting, identify the Total Installed Watts, as defined in OLTG-2-C, Part 1 of 4.
3. Multiply the wattages by the Equivalent Full Load Hours of Operation, and divide by 1,000 to get annual electricity consumption in kWh/year (e.g. if the exterior lighting operates 12 hours daily, the equivalent full load hours is 365 days * 12 hours = 4,380 hours).
4. Calculate the energy cost for exterior lighting by multiplying the annual electricity

consumption by the virtual utility rate for electricity (which is shown on form ECON-1).

5. Include the combined cost in Tables 1.8.1b and 1.8.2b.
6. The electricity cost should be the same for the Baseline and Proposed cases.

For EnergyPro for Specific Applications (Table 147-B):

Identify the Allowed Watts from OLTG-2-C (Part 3 of 4) Column P. Use these watts for the both the Standard and the Proposed lighting power. Proceed as outlined in the paragraph above.

Reporting Unconditioned Space Lighting Energy in EAc1 LEED Template

Unconditioned space lighting, including parking garage lighting, may be modeled using the allowable lighting power density in the Title-24 Standard Case, and the installed lighting power density in the Proposed Case. However, it is important to understand that the annual energy use of lighting in unconditioned spaces is not included in the calculated total energy use from EnergyPro; the program only reports the allowed and actual lighting power in such spaces. As a result, the values from EnergyPro need to be used to manually calculate the annual energy use for these systems for inclusion in the LEED EAc1 submittal. To calculate the lighting energy consumption for unconditioned spaces in EnergyPro:

1. Input the unconditioned spaces in EnergyPro.
2. Select the space category for the unconditioned space, and mark the space type as 'unconditioned'.
3. Input the lighting as you would for a conditioned space.
4. After running the simulation, find the Total Allowed Watts for unconditioned spaces in LTG-5-C.
5. Find the total installed Watts for unconditioned spaces in LTG-2-C.
6. For the Title-24 standard case, multiply the unconditioned space allowed Watts by the Equivalent Full Load Hours of Operation (EFLH), and divide by 1,000 to get annual electricity consumption in kWh/year (e.g. if the unconditioned space lighting operates 40 hours per week, the EFLH is 52 weeks * 40 hours = 2,080 hours).

7. For the Title-24 proposed case, multiply the unconditioned space installed Watts by the EFLH, and divide by 1,000 to get annual proposed electricity consumption in kWh/year (the EFLH should be the same as for the Title-24 standard case).
8. Calculate the energy cost by multiplying the annual unconditioned space lighting consumption by the virtual rate for electricity.

Exceptional Calculation Methodology

Energy efficiency measures not accounted for within Title-24 compliance analyses may be modeled using the Exceptional Calculation Methodology, similarly to ASHRAE 90.1-2004 Appendix G buildings. For example, fan energy savings from underfloor air conditioning, electricity savings from EnergyStar appliances, Lighting in residential dwelling units, etc. may be modeled using the Exceptional Calculation Methodology. If the exceptional calculation methodology is used, a narrative should be provided describing the inputs for the standard and proposed case. The narrative should provide sufficient documentation to justify the standard case assumptions, and should describe the calculation methodology used to project the energy savings. Section 1.7 of the LEED EAc1 template should be used to report the energy savings.

SITE-GENERATED RENEWABLE ENERGY

Site-generated renewable energy may be added to the energy savings in the EAc1 documentation. Section 1.6 of the LEED Template should be used to document the energy offset by site-generated renewable energy. The energy produced by the renewable energy system is typically calculated using a stand-alone analysis program, such as PV Watts, a free web-based program that estimates the energy production of photovoltaic systems.

Collaborative for High Performance Schools (CHPS)

The Collaborative for High Performance Schools (CHPS) criteria are a flexible yardstick that allow design teams to create a green building based on their particular projects opportunities and constraints. Like LEED and other green building rating systems, CHPS addresses more than just energy efficiency. CHPS criteria include Sustainable Sites, Water, Energy, Materials, and Indoor Environmental Quality.

In terms of energy modeling methodology and documentation requirements, CHPS is similar to Savings By Design in that performance is measured on a Time-Dependent Valuation (TDV) method. As a result, the output produced by Energy Pro and other State-approved Title 24 compliance software can be used for CHPS documentation with little or no modification.

CHPS has a prerequisite (EE1.0) for minimum energy performance which stipulates that projects must exceed 2005 Title 24 requirements by at least 10 percent. To document this, submit the PERF-1 forms for the energy model that reflects the final design. It is important to note that this is a prerequisite that all CHPS projects must earn, which underscores the importance of using energy modeling during earlier project phases to determine if the proposed design is anticipated to meet this requirement.

CHPS credit EE1.1 “Superior Energy Performance” offers up to 13 points for going 12 to 36 percent beyond the requirements of 2005 Title 24. Like EE1.0, the documentation necessary for the CHPS submittal consists of the PERF-1 documentation from a State-approved Title 24 compliance software program.

For school projects offered in areas where the Savings By Design program is offered, it is commonly the case that a project will also submit for Savings By Design incentives. To produce the necessary documentation for Savings By Design, select the additional required forms from the EnergyPro report wizards (UTIL-1, UTIL-DT, ECON-1) and include those in the Title 24 report.

A central component of the high performance building process is that the energy efficiency and cost-effectiveness of design decisions can be improved through effective use of energy modeling during all design phases of a project. The challenge to the energy modeler is to understand which questions can be effectively answered with the energy model at each project phase. Just as the overall design starts with a broad focus during schematic design and increases in detail through subsequent phases, so too must the energy model start as a somewhat simplified depiction of what the final project will be and then be refined as more detailed information becomes available. The energy modeler must apply their judgment and experience to know which details are important at each project phase and which design questions can be answered appropriately at different project phases.

While incentive programs such as Savings By Design and green building rating systems such as LEED and CHPS introduce an added level of technical and documentation requirements for the energy model, the best approach for successfully navigating through these requirements is to have a detailed understanding of what is expected. Experience shows that Savings By Design, LEED and CHPS reviews go more smoothly and with fewer corrections required if the energy model is developed based on the specific requirements for the particular program and if complete and appropriate backup documentation is provided.

For Further Information

- **Collaborative for High Performance Schools**

(www.chps.net) The Collaborative for High Performance Schools (CHPS) website provides downloadable information about the CHPS green building rating system, as well as its variants that have been developed for specific U.S. States.

- **Energy Design Resources**

(www.energydesignresources.com) Energy Design Resources (EDR) is a source of free information on a variety of energy efficiency subjects including building simulation, integrated design, daylighting, and high performance HVAC systems. EDR offers case studies, energy analysis software, design briefs, and training for the designers, owners, and operators of commercial buildings. EDR was developed by California's investor-owned utilities.

- **Savings By Design**

(www.savingsbydesign.com) The Savings By Design website provides the latest information about commercial new constructive incentives and design assistance for projects located in the service territories of California's investor-owned utilities.

- **United States Green Building Council**

(www.usgbc.org) The USGBC website provides information on the various versions of the LEED rating system, as well as information about how to register and certify LEED projects.

www.energydesignresources.com

