

Key Topic Area Descriptions**for Proposed Changes to the 2008 California Building Energy Efficiency Standards**

(Taken from the Request for Qualifications for an Outside Contractor -
January 2005)

The topic areas initially identified for possible changes to the Energy Standards include but are not limited to the list below. The list is evolving, and some of the topics below may drop from the list as time progresses. Additional topic areas may be identified by Commission staff or proposed by the public through workshops, hearings, or other comment avenues.

A. Demand Response

The Energy Commission and the California Public Utilities Commission are conducting a joint proceeding to develop policies and practices for advanced metering, demand response, and dynamic pricing (www.energy.ca.gov/demandresponse). The Schwarzenegger Administration has recognized demand response as a critical means to avoid rolling blackouts in the electricity system and is actively interested in approaches that can be taken in the building energy efficiency standards to require equipment that will facilitate demand response. Southern California Edison is pursuing a Codes and Standards Enhancement (CASE – see Section N below) Initiative that would investigate Standards requirements for demand responsive thermostats. Such thermostats would communicate with advanced electricity meters and be remotely addressable by the utility to communicate periods when the electricity system is low on resources and in emergency alert stages and critical peak pricing (CPPP) periods when the cost of electricity is very high. Such thermostats would be programmable by the building occupant to automatically set up the thermostat setpoint to call for less cooling during such events. The Administration also is interested in the potential for the Standards to require advanced meters that would be addressable by the utility during such events and would communicate with demand responsive thermostats and possibly with other demand responsive controllers to reduce the loads of specific equipment during such events. The Edison project also may investigate the potential for demand responsive controls for other end use equipment, such as swimming pool pumps based on pilot projects conducted as part of the joint CEC/CPUC demand response proceeding. In addition, the Energy Commission's Public Interest Energy Research (PIER) program has conducted research on addressable electronic lighting ballasts that could be dimmed automatically during such events. Similar automatic demand responsive control also is feasible for components of HVAC systems. The Contractor will use all available information to investigate inclusion of these demand responsive approaches in the Standards, including development of detailed minimum specifications for communication and control capabilities and acceptance requirements and procedures for acceptance requirement verification.

B. Tier II Standards Option - Benchmark for the Combination of High Energy Efficiency and Photovoltaics

The Schwarzenegger Administration has a high commitment to vigorous expansion of the use of photovoltaics (PVs) to power California buildings. The Administration has been working with stakeholders on its "Million Solar Roofs Initiative," which will provide substantial public-funded incentives for PVs with a goal of making California one of the world leaders in the use of PVs and in the process driving down the cost of PVs here so that at the end of a ten year period they will be fully sustainable in the market without further public incentives. In developing this

initiative, the Administration recognizes that PVs will be most cost effective when installed in combination with effective energy efficiency measures that substantially exceed current requirements in the Standards. When the Administration publicly announces its Initiative in the near future, it is expected that a higher level of incentives will be earmarked for homes that have the combination of high energy efficiency and photovoltaics. This is consistent with the concept of Zero Energy New Homes (ZENH) that has been initiated by the U.S. Department of Energy (DOE) throughout the U.S. Recently, the Commission has launched a major research and demonstration program for ZENHs in California.

The Commission intends to develop a Tier II compliance option in the 2008 Standards that will create a benchmark for homes with the combination of effective high energy efficiency measures and PVs. The effectiveness of all of the installed measures will be assured by third-party field verification and diagnostic testing. This Tier II compliance option will serve as a criterion for higher incentives through the Million Solar Roofs Initiative and for incentives that utilities may provide to further promote combined high efficiency/PV homes in California. The Commission also will consider regulatory incentives for homes that choose to comply with Tier II, such as potentially waiving building department energy plan check and site inspection for these homes.

The Contractor will provide technical analysis for the development of the Tier II compliance option. The Commission intends for the Tier II level to be specified in terms of its performance standards and for compliance software to automatically determine the "Tier II energy budget" based on the high energy efficiency measures that the Commission chooses (the Commission also will consider including solar domestic water heating in the set of measures). The Commission also intends to incorporate in compliance software determination of the expected performance of the PV system taking into account factors that impact PV output, including rated efficiency at standard test conditions, ambient temperature by climate region, dirt and dust, module mismatch and system wiring losses, DC to AC conversion losses, sun angle and module orientation and tilt, ventilation between the module and the roof, shading of the roof resulting from the above roof installation of the module, and expected shading of the module from neighboring trees. The contractor will evaluate the cost effectiveness of alternative energy efficiency measures compared to the cost of electricity generated by PVs.

C. Reference Computer Program

California's Standards are fundamentally performance standards requiring the use of building computer simulation programs for evaluating the cost effectiveness of Standards requirements and for determining compliance. The Commission uses a specific computer program, DOE2.1E, for Nonresidential Standards development and as the "reference" program against which other programs proposed to be used for compliance are compared. The Alternative Calculation Methods (ACM) Approval Manual specifies detailed modeling approaches used in the reference program and rules for capabilities that will be necessary for other programs to have to be approved for compliance. Currently, approved nonresidential compliance programs use DOE2.1E as their engine. DOE2.1E was developed and maintained by Lawrence Berkeley National Laboratory (LBNL) through public funds. However, over the past several years LBNL has not made substantial improvements to DOE2.1E to incorporate new technologies and or make improvements to the software. Instead, DOE and LBNL have been focusing their efforts on developing a new program, EnergyPlus, that is designed to be a fundamentally more accurate program with substantially greater ability to model new technologies. EnergyPlus was originally called "Best of" because it was designed to combine the best features of both DOE2

and BLAST into a superior program. The Commission has been considering whether to change the reference program for the Standards to EnergyPlus and discontinue the use of DOE2.1E.

There are a number of considerations to be made regarding this change. The Warren-Alquist Act requires the Commission to provide a public domain compliance software program for the Standards. The Commission has met this requirement by providing software that uses DOE2.1E as its engine and meets all ACM Manual rules related to measure modeling and input and output formatting. EnergyPlus is an engine alone without the interfaces necessary to meet the ACM requirements for compliance software. For the Commission to provide an EnergyPlus-based compliance program, the substantial work of developing the necessary interfaces would have to be done. Because EnergyPlus has no interfaces to facilitate its use, modeling of features for Standards development is more difficult. EnergyPlus also was not designed to comply with the ACM rules for how to model buildings and features. It does not incorporate all measures required by the ACM rules and differs in how it models some features. Also, it is anticipated that EnergyPlus will result in somewhat different energy estimates for particular buildings and measures. At this point in time it is not known how significant these differences are.

Two Public Goods Charge-funded projects are analyzing EnergyPlus and will provide useful information for the Commission to decide whether to switch to EnergyPlus. First, PG&E is conducting a project to evaluate in detail to what extent EnergyPlus conforms to current ACM rules. Differences are being identified, and the project will recommend whether EnergyPlus should be modified to match the ACM rules or perhaps that some ACM rules should be considered for updating to enable EnergyPlus modeling improvements relative to DOE2.1E to be acceptable for the Commission's reference program. Second, Southern California Edison is conducting a project to provide a detailed comparison of EnergyPlus with other prominently used programs, including EnergyPro (the currently approved nonresidential compliance program based on DOE2.1E) and DOE2.2, a privately developed upgrade of the DOE2 engine.

The Commission intends to consider switching to EnergyPlus as the Standards reference program in conjunction with the 2008 Standards. In so doing the Commission will carefully consider the results of both of the above projects. Also, the Commission expects the Contractor to use EnergyPlus to the extent possible for evaluating nonresidential measures for the 2008 Standards. If the Commission chooses to switch to EnergyPlus, the Nonresidential ACM manual will have to be updated to apply to EnergyPlus. Descriptions of modeling will have to be presented in terms of EnergyPlus inputs, outputs, and modeling approaches. Modeling limitations in the ACM will need to be reconfigured to be consistent with EnergyPlus modeling approaches. LBNL and DOE in conjunction with PIER have committed to provide ongoing assistance and support to enable the potential use of EnergyPlus for Standards development, to help develop the necessary interfaces to insure that the Commission can provide nonresidential compliance software based on EnergyPlus, and to facilitate the introduction of alternative compliance software by other providers that use EnergyPlus as the engine. The Contractor will provide technical assistance to enable switching of the reference program to EnergyPlus if the Commission decides to make that switch in conjunction with the 2008 Standards.

D. Modeling of Residential Roof and Attic Measures

The energy using characteristics of attics and roofs have important energy and peak demand impacts on homes in California climates. Homes with low reflectance roofs and limited attic ventilation have attics that reach temperatures significantly higher than outdoor temperatures on hot days. These very high attic temperatures increase cooling loads and peak electrical demand

by driving heat through the ceiling and reduce the efficiency of the air conditioning equipment ducts that are located in the hot attics. There are significant opportunities for improving attic conditions and reducing energy consumption and peak demand, including cool roofs, radiant barriers, improved attic ventilation, causing the attic to be in conditioned or semi-conditioned space, and increased thermal mass of roofing materials or ventilation of the roof surface. However, current residential modeling tools are not capable of accurately differentiating the energy consequences of these various roof and attic measures. PIER is sponsoring research to improve the attic/roof model to better evaluate the relative benefits and potential interactive impacts of these measures. For the 2008 Standards, the results of this PIER project must be incorporated into the ACM manuals. The Contractor will provide technical support to accomplish this.

E. Ventilation for Indoor Air Quality

ASHRAE Standard 62, Ventilation for Indoor Air Quality, has long been the accepted standard for designing HVAC systems to provide adequate ventilation to maintain indoor air quality. The Standards have relied on ASHRAE Standard 62 to define minimum ventilation rates, acceptable ventilation strategies, and energy efficient ventilation approaches. ASHRAE adopted a new version of Standard 62.1 in 2002 for nonresidential buildings; this new version has been written in code language. Also, the 2003 UMC has adopted ASHRAE 62.1 by reference. The Contractor will identify what aspects of ASHRAE 62.1 differ from the Standards, identify desirable changes to the Standards to narrow those differences, evaluate the energy savings implications of making those changes, and develop approaches to mitigate situations where changing the Standards to be more like ASHRAE 62.1 would lead to increases in energy use and peak demand.

The 2005 Standards mandate demand control ventilation (DCV) when the air handler serves a space with a design occupant density (or with a maximum occupant load factor for egress purposes in the CBC) greater than or equal to 25 people per 1,000 ft² (40 ft² per person). The Contractor should consider expanding this requirement for occupancies with lesser densities.

ASHRAE also recently adopted Standard 62.2 for residential buildings. PIER is sponsoring research to assess to what extent the Standard 62.2 requirements would be appropriate for California. Also, the California Air Resources Board (ARB) is conducting research to evaluate the common practice of opening windows to maintain adequate indoor air quality and the emerging use of whole-house mechanical ventilation. As part of the PIER work, an evaluation will be made as to whether or not the Standards should be changed to be based on mechanical ventilation and what changes would need to be made to the Standards and ACM manuals. The Contractor will provide technical support to integrate the results of the PIER and ARB research into the Standards.

F. Nonresidential Ducts

The 2001 Standards included duct sealing in residential units in prescriptive package D. The 2005 Standards extended nonresidential prescriptive duct sealing requirements to single zone units serving areas 5,000 square feet or less when ducts are installed outside of conditioned space. For the 2008 Standards, the Commission will consider extending the duct sealing requirements in nonresidential buildings to multizone (MZ) and variable air volume (VAV) systems in larger buildings. PIER has sponsored extensive research related to sealing of these duct systems and improvements to the modeling of these types of duct systems. The contractor will provide technical support to develop ACM algorithmic changes, duct sealing and diagnostic

testing protocols for installers and Home Energy Rating System (HERS) raters, and cost effectiveness and other justification necessary to support requiring duct sealing for these systems in the Standards.

Another potential nonresidential duct efficiency measure for the 2008 Standards is “cool ducts.” Some metal ducts installed on the exterior of nonresidential buildings are exposed to direct sun, which can substantially heat the cool air inside the ducts resulting in loss of cooling capacity. Similar to certain roof materials, the outside of these duct systems can be treated with “cool” coatings that have high reflectivity and emissivity, resulting in substantial cooling savings. PIER recently has completed research evaluating the cost effectiveness of cool ducts. The Contractor will provide justification and documentation to enable the requirement of cool ducts in the Standards.

PIER has been conducting research for some time on underfloor air distribution and thermal displacement ventilation systems, and the research indicates that these techniques may result in significant energy savings and improve ventilation effectiveness. The Contractor will develop approaches to either provide compliance credit or require these systems in appropriate situations, including documentation and justification of Standards and ACM manual revisions.

G. Federal Requirements for State Building Energy Codes

The Federal Energy Policy Act of 1992 (EPAAct) requires States to use national consensus standards as benchmarks to assess the adequacy of state building energy codes. Whenever the International Code Council (ICC) updates these standards [known as the Model Energy Code (MEC) or International Energy Conservation Code (IECC)], DOE must determine if the new version is more energy efficient than the previous version. States must then review their residential building energy codes to determine if they meet or exceed the efficiency of the national consensus standards. The Commission intends in the 2008 Standards to consider changes to keep California’s Residential Building Energy Efficiency Standards more energy efficient than the 2003 IECC and relevant supplements. The Contractor will identify requirements within the IECC that are more energy efficient than counterpart requirements in the Standards.

Similarly, when ASHRAE updates its Standard 90.1, DOE is required to determine whether it is more energy efficient than the previous version. If DOE determines that this is the case, state building energy codes for nonresidential and high-rise residential buildings must be changed to be at least as energy efficient as the new version of ASHRAE 90.1. ASHRAE is now maintaining ASHRAE 90.1 as a “continuous maintenance” standard. The Commission intends in the 2008 Standards to consider changes to keep California’s Nonresidential and High-Rise Residential Building Energy Efficiency Standards more energy efficient than ASHRAE 90.1. The Contractor will identify requirements within ASHRAE 90.1 that are more energy efficient than counterpart requirements in the Standards.

Though Federal law requires that state energy codes be at least as stringent as ASHRAE 90.1, the Warren-Alquist did not include Type I occupancies, e.g., hospitals, within the scope of buildings that are required to comply with the Standards. The Office of Statewide Health Planning and Development (OSHPD) is the agency in California that has authority for adopting building standards for hospitals. For the 2008 Standards, the Commission intends to provide technical assistance to OSHPD to identify the portions of the Standards that would be appropriate for OSHPD to adopt as energy efficiency standards for hospitals and to develop modifications to those portions as needed to address the design and operational requirements

of hospitals. Through this process the Commission intends to demonstrate that the requirements for state energy codes in federal law are met for California hospitals.

H. Duct Tape and Fittings

The 2001 Standards established requirements that prohibited the use of cloth-back rubber adhesive duct tape unless it is used in combination with mastic. Duct tape manufacturers petitioned the Commission for reconsideration of this prohibition in 2002, and following a rulemaking proceeding to consider the manufacturers' petition, the Commission concluded that no change should be made to the Standards (www.energy.ca.gov/title24/ducttape/notices/2002-03-26_COM_CONCLUSIONS.PDF). At the time the prohibition was adopted the Commission recognized that it would be preferable to state a durability performance standard for duct sealing products rather than prescriptively prohibit the use of a particular product type. However, no satisfactory consensus-adopted test procedure for duct sealant durability existed. Lawrence Berkeley National Laboratory (LBNL) has done work funded originally by DOE and more recently by PIER to seek approval by the American Society for Testing and Materials (ASTM) for the duct sealant durability testing protocol (ASTM E2342-03) that underlies the prohibition of cloth-back rubber adhesive duct tape in the Standards. The test procedure specifies how the testing is to be carried out but it does not specify a time-to-failure requirement. LBNL recently completed a report of its PIER-funded work on duct sealants that makes a recommendation for a time-to-failure specification. The Contractor will develop and justify Standards revisions to call for ASTM E2342-03 testing of duct sealant products including a time-to-failure specification.

Recently, some manufacturers and installers of residential ducts have developed innovative duct joints that are self-sealing and do not require tapes, mastic, or clamps. Portions of these ducts may be assembled at the factory and other parts may be assembled at the site. The installation of these duct fittings may be substantially less labor intensive than conventional duct closure ducts, resulting in first cost savings. For the 2008 Standards, the Commission intends to develop installation protocols for these types of ducts to ensure proper installation, and to allow their use as part of the duct sealing compliance option. The contractor will provide technical support for evaluating the appropriateness of this change.

I. Feedback on and Refinement of 2005 Standards

As the 2005 Standards are implemented, the Commission expects to receive feedback on how to refine them to be more effective. The contractor will provide technical support to evaluate potential refinements and develop needed changes to the Standards and ACM manuals.

J. Time Dependent Valuation

Prior to the adoption of the 2005 Standards, energy efficiency measures considered for inclusion in the Standards were expressed in terms of source energy. The valuation for alternative measures for achieving compliance with the Standards depended on how much source energy was determined to be reduced (or increased) by installing the measures in buildings. However, the costs for providing electricity, natural gas, and propane vary hourly and seasonally, and measures that reduce electricity, gas, or propane use during their peak periods have greater value to the energy system than at off-peak times. Therefore, the Commission adopted a time dependent valuation (TDV) approach for evaluating energy efficiency measures beginning with the 2005 Standards.

TDV changes the basis for valuing alternative energy measures within the Standards performance approach. Under TDV, the performance standards are a function of the present value dollar cost of energy for each hour and season over the life of the building. The value for alternative measures for achieving compliance with the Standards depends on how much installation of the measure reduced (or increased) the building's TDV-dependent energy consumption over the measure's useful life.

Currently, the California Public Utilities Commission (CPUC) is conducting a proceeding to develop rules for Public Goods Charge-funded energy efficiency programs for program years 2006 to 2008. One area under consideration is whether time-dependent "avoided costs" should be used for determining the cost effectiveness of Public Goods Charge programs. The CPUC has re-evaluated what the "avoided costs" for each hour of the year should be. For the 2008 Standards, the Contractor will review the CPUC effort to determine if the TDV valuation in the 2005 Standards should be changed to be based upon the CPUC's new avoided costs.

K. Performance Verification/Acceptance Requirements

Research conducted by Architectural Energy Corporation (AEC), Lawrence Berkeley National Laboratory (LBNL), PG&E and other researchers throughout the country has demonstrated that major energy consuming systems in nonresidential buildings are commonly poorly "commissioned" at the time of building construction, and therefore fail to perform as intended by the building designers. Prior to the adoption of the 2005 Standards, the Standards addressed only limited aspects of how a building is to be tested and commissioned to assure it performs as designed (primarily related to HVAC system balancing and ventilation design). Research showed a need to place substantially more attention on verification and commissioning of HVAC equipment (including package rooftop units, ductwork, economizers, and controls) and of lighting system controls as well.

In the 2005 Standards, the Commission adopted a set of mandatory "acceptance requirements" for testing of HVAC and lighting systems to make sure they are installed properly to meet the Standards. The building permit applicant must provide a signed Certificate of Acceptance to the enforcement agency that shows that specified tests were performed and that the systems performed as designed in compliance with the Standards. The enforcement agency is not allowed to grant an occupancy permit until it receives the Certificate of Acceptance. The testing can be done and the certificate of acceptance can be signed by a member of the builder's team, including for example the design engineer, the installing contractor or a specialty contractor (e.g., a HVAC test and balance contractor) that the builder hires to do the testing. The items to be tested include VAV systems, constant volume systems, packaged HVAC systems, air distribution systems, hydronic system controls, air economizer controls, demand control ventilation (DCV) systems, variable frequency drive systems, and lighting control systems. These requirements are in Standards Sections 10-103, 121, and 125, and in Appendix NJ of the Nonresidential ACM Manual. Chapter 8 of the 2005 Compliance Manual contains detailed instructions for complying with the acceptance requirements.

After the 2005 Standards were adopted, certain improvements to the acceptance requirements were proposed for areas including but not limited to calibration of thermostats and flow measurements in hydronic systems. These and other possible improvements will be addressed by the contractor in the 2008 Standards.

Failure of HVAC and lighting systems to be installed and operated as designed also can be attacked by automatic means that function throughout the systems' operational life. These

automatic approaches include on-board detection of faults (when equipment begins to fail to operate within design parameters) and diagnostic controls to determine the reason for the faults and potentially even to automatically alter the equipment operation to correct the faults. Fault detection and diagnostic controls that are installed at the time of installation of the systems continue to monitor the operation of the mechanical or lighting equipment throughout the life of the equipment. These monitoring devices alert the owners/operators to any faults within the systems, and enable and facilitate corrective action. A recent PIER project has investigated issues related to automated fault detection and diagnostic software for air handling units (AHU) and VAV boxes.

Another automatic approach is to install controls that continually monitor the systems operation, and provide output that can be trended and compared to expected operation patterns to enable the operator to identify and correct operational problems that come up that cause increased energy use but may otherwise not easily be detected. This approach often is implemented as automatic data that is reported to an energy management system for analysis and reporting. The installation of these types of automatic approaches at the time of installation of systems can be a very powerful energy savings strategy that persists over the operational life of the system. PIER is evaluating automatic trend data collection and analysis systems that provide operators with real-time assistance to adjust system operation.

These automatic approaches can serve a similar function as acceptance requirement testing resulting in systems being installed properly to achieve design and Standards compliance intent. The Commission intends in the 2008 Standards to evaluate the appropriateness of relying on automatic approaches as alternatives to the acceptance requirements. This approach would require the establishment of minimum capabilities for such automatic approaches and the development of acceptance requirements for the automatic fault detection and diagnostic testing controls or the automatic trend data collection and analysis systems. The Contractor will provide technical support for developing and justifying these alternatives. The Contractor must be familiar with the research and relevant PIER projects and integrate the results into the 2008 Standards as appropriate.

L. Residential Construction Quality

Since 1998 the Commission has placed priority on Standards requirements and compliance options to achieve quality installation of energy efficiency measures in residences. The Commission intends to continue that effort for the 2008 Standards. The Contractor will analyze the need for updating the protocols and calculation methods for the following residential features:

- Duct Sealing
- Supply Duct Location, Surface Area, and R-factor
- Improved Refrigerant Charge
- Installation of Thermostatic Expansion Valve (TXV) (some questions have been raised about the effectiveness of TXVs)
- Maximum Cooling Capacity
- Building Envelope Sealing
- High Quality Insulation Installation

The California Mechanical Code (CMC) requires residential duct systems to follow the Air Conditioners Contractors of America (ACCA) Manual D for duct design. However, the CMC is silent on the need for third party field verification to insure that proper design procedures are

actually followed and result in proper supply duct airflow. The Contractor will analyze the potential for making adequate airflow through ducts a prescriptive requirement.

The federally required procedures for air conditioner efficiency (the Seasonal Energy Efficiency Ratio, SEER) allow manufacturers to use an assumed (default) air handler fan watt draw instead of measuring the actual fan watts of the equipment. Unfortunately, field research has shown that the actual fan energy in typical equipment is substantially greater than the default value that manufacturers are allowed to claim. The 2005 Standards created a compliance credit to encourage approaches to reduce actual fan energy; the credit can be taken when confirmed through third party diagnostic testing in the field. The same air handler fan is commonly used for distributing furnace heating through the duct system. On the heating side the fan energy is completely left out of the federal furnace efficiency ratings. PIER is currently evaluating air handler fan energy use during heating, and investigating the development of diagnostic testing protocols and calculation methods to include heating fan energy use in Standards compliance. The Contractor will provide technical support to the documentation and justification of Standards and ACM changes.

In the 2005 Standards the Commission revised the framing factors, used for determining wall assembly U-factors. Those framing factors are based on research findings for average California framing installations. Substantially lower framing factors are potentially possible through more careful attention to limiting the amount of framing, particularly at corners and window framing. The Commission intends to assess the appropriateness of compliance credit for field verified low framing percentage techniques. In the 2005 Standards the Commission also discontinued the practice of unique determination of assembly U-factors by calculations in the field. Instead, the 2005 Standards establish look-up tables of assembly U-factors for specified assemblies. The Commission intends to review the look-up tables (Joint Appendix IV) to determine if revisions or additions are appropriate. In the 2005 Standards the Commission established compliance credit for high quality installation of insulation. These compliance credits apply to conventional blown and batt insulation installed within framing members. However, compliance credit does not exist for other types of insulation approaches, such as structural insulated panels. The Commission intends to consider developing field verification protocols for proper installation of these additional insulation approaches to provide a path for compliance credit for high quality installation. The contractor will provide technical support for these.

Recently, some manufacturers and installers of residential ducts have developed innovative duct joints that are self-sealing and do not require tapes, mastic, or clamps. Portions of these ducts may be assembled at the factory and other parts may be assembled at the site. The installation of these ducts may be substantially less labor intensive than conventional ducts, resulting in first cost savings. For the 2008 Standards, the Commission intends to develop installation protocols for these types of ducts to ensure proper installation, and to allow their use as part of the duct sealing compliance option. The contractor will provide technical support for evaluating the appropriateness of this change.

M. Water Heating

PIER is planning to sponsor the investigation of several issues related to energy used in the distribution of hot water. The scope of PIER's research is not fully determined at this time, but the following issues are being considered.

1. Demand Controlled Circulation Loops in Multi-family Buildings

Central water heating systems are common in multi-family buildings. These central systems typically are recirculating systems with a circulation loop that distributes hot water to each of the dwelling units in the building. The circulation loops can be controlled in a variety of ways: thermosiphon, 24-hour pumping, timer controls, temperature controls (aquastat), time and temperature controls, and demand controls. Demand control circulation loops generally operate less than one hour per day, roughly one tenth the operating time of the best of the other alternatives, and roughly one tenth the energy consumption for both the loop and the pump. This investigation would determine the appropriateness of establishing a prescriptive requirement for demand control circulation loops in these buildings.

2. Modulating Controls for Boilers with Storage Tanks in Multi-family

Modulating controls are an efficient means to control central systems. These controls can modulate the temperature of the storage tank based on the hot water use patterns in the building; they keep the temperature higher during periods of peak hot water use and lower during other periods. This investigation would determine the appropriateness of requiring modulating controls for central boiler systems in multi-family buildings.

3. Piping installed under slabs

Recent testing suggests that heat loss in water pipes installed underneath slabs is three times that of pipes installed above grade. This investigation would determine whether there should be requirements to disallow installation of hot water pipes under slabs.

4. Heat transfer between hot and cold piping

For both copper and crosslinked polyethylene (PEX) piping, installation practices tend to run hot and cold lines in close proximity to each other, and in many cases, actually bound to each other. There may be a significant amount of heat transfer between the hot and cold pipes. This investigation would determine whether there should be a requirement that hot and cold lines be separated from each other.

5. Pipe Insulation

The 2005 Standards introduced prescriptive pipe insulation requirements for hot water pipes from the water heater to the kitchen for pipes $\frac{3}{4}$ inch in diameter or greater. This investigation would review the potential energy savings from pipe insulation accounting for the different environments that the pipe may be in to determine if pipe insulation requirements should be changed.

6. Distribution System Multipliers

The Standards address the extent of energy used by hot water distribution systems by establishing multipliers to adjust the energy used by the water heater with standard trunk and branch piping systems. Separate multipliers are

established for five ways to control circulation loops: 24-hour pumping, timer controls, temperature controls (aquastat), time and temperature controls, and demand controls. Multipliers also are established for hot water recovery, point of use, and manifold systems. The 2005 Standards updated these multipliers based on recent analysis conducted by Davis Energy Group. This investigation would review the distribution system multipliers to determine if there is more current information that would warrant changing these distribution multipliers. This investigation also would consider changing the temperatures for the different spaces where distribution piping can be located to track hourly changes in these temperatures throughout the year to better match the TDV-based analysis approach in the Standards.

7. Multiple Water Heaters

For larger homes and in particular for large single story homes, the impact of standby losses of hot water tanks may be less than that of extensively long distribution systems. This investigation would conduct analyses to compare the energy and water use resulting from the length of pipe runs and from multiple water heaters. The investigation would determine if a change to the Standards would be to prefer the use of multiple water heaters for homes with long distribution systems.

8. Verify accuracy of current hot water heating algorithms

Changes have been made over time in the algorithms for hot water heating systems. The most significant change was made to allow the computer models to be based on the energy factor descriptor established for federal water heater standards. This change did not address standby energy losses in a way that was directly comparable to other water heating system types as was done with earlier modeling approaches. Also, the current water heating modeling does not separately address primary and secondary storage tanks. This is a significant concern to properly measure standby loss in all systems and to allow for proper modeling of solar water heating systems. The investigation would determine the appropriateness of revising some of the algorithms and modeling assumptions used in the residential water heating model to better address standby energy.

9. Reliability of Energy Savings from Tankless Water Heaters

Energy estimates that are based strictly on the efficiency of the tankless water heaters compared to water heaters with storage tanks indicate that tankless water heaters are substantially more efficient. However, tankless water heaters may not meet consumer demands for providing adequate amounts of hot water, potentially resulting in the installation of supplemental storage tanks that negate the expected energy savings benefits of the tankless water heater. This investigation will evaluate the extent to which performance characteristics of tankless water heaters may lead to installation of supplemental storage tanks, and potential solutions to this problem that could be addressed in the Standards. Potential solutions could include minimum requirements for tankless hot water heaters that insure that consumer demand for hot water will be met without installation of supplemental storage tanks or revision of the compliance credit for

tankless water heaters to recognize the potential for installation of supplemental storage tanks.

10. Nonresidential Prescriptive Requirements for Electric Water Heaters

Late in the 2005 Standards proceeding concern was raised that the nonresidential standards allow electric water heaters to be used for prescriptive compliance without any offsetting energy efficiency improvement to account for the greater energy used by electric water heaters compared to natural gas water heaters. This creates a difference in stringency between the nonresidential prescriptive approach and the performance approach where the standard design is based on gas water heating and the energy difference for electric water heaters must be made up to achieve compliance. This issue was raised too late in the 2005 Standards proceeding for it to be addressed. This investigation would consider options for addressing this problem including the approach that is used in the residential standards.

Contingent on which of these issues are included in the scope of the PIER water heating research, the Contractor will provide technical support to produce the justification and documentation necessary for the Commission to consider specific changes based on the research in the 2008 Standards and ACM manual calculations.

N. Codes and Standards Enhancement Initiatives

The investor-owned utilities (IOUs) conduct the statewide Codes and Standards programs through Public Goods Charge funding. For the 2008 Standards, the IOUs are conducting several Codes and Standards Enhancement (CASE) Initiatives. These initiatives address areas of potential change to the Standards that are promising based on the experience of utility research and incentives programs, and they document the potential energy savings, cost implications, and specific approaches associated with utility proposals for Standards changes. PG&E intends to conduct CASE initiatives for the following topic areas:

Residential 1	Window Performance Requirements	Upgrade residential window U-Factor and Solar Heat Gain Coefficient requirements to reflect currently available technology.
Residential 2	Pool pumps	Incorporate requirements for single-family residential pool pumps into the mandatory measures, for example: two-speed pumps and motors, time clocks that accommodate two-speed operation and design features, such as limiting the flow velocity to encourage proper pipe sizing appropriate to pump selection.
Residential 3	Cool roofs	Consider adding high-slope cool roofs as a prescriptive requirement.
Nonresidential 1	Insulation Levels	Review literature and increase prescriptive insulation requirements, as appropriate.
Nonresidential 2	Indoor Lighting -	Review ASHRAE, IESNA, and other literature, and recent technological advances and recommend lower lighting power densities (LPDs) as appropriate, including retail lighting and the tailored method.

		Additionally, review present standards for incorrect conversion from Lux to foot-candles and correct these errors. Add or convert T-24 to Lux-based standards.
Nonresidential 3	Lighting Controls, Performance Approach	Revise control credits for the performance approach based on best available monitoring data so that they accounts for hourly benefits consistent with the TDV-basis of the Standards.
Nonresidential 4	Outdoor Lighting	Analyze the outdoor lighting LPDs in terms of improvements in technology and practice to determine if there are cost effective changes that can be made.
Nonresidential 5	Outdoor Signs	Review the requirements for outdoor signs to determine if there are cost effective changes that can be made to promote more efficient sign illumination, including requirements for channel letter signs and linear architectural uses of neon.
Nonresidential 6	Lighting / Envelope / Daylighting	Expand the skylighting requirements to include smaller buildings and buildings with lower ceilings.
Nonresidential 7	Overall Envelope Approach	Review the overhang and shading credits and envelope tradeoff procedures in Standards Section 143(b) to determine if they should be changed to reflect the hourly benefits consistent with TDV.
Nonresidential 8	Refrigerated Warehouses	Develop envelope and mechanical requirements based on best practices currently in the industry, including revision of the temperature conditions for exemption of buildings with process energy functions. Analyze potential for improving modeling and Standards requirements for walk-in coolers and freezers.
Nonresidential 9	Alterations	Require lighting systems to meet T24 requirements when 30% of the fixtures are being replaced during alteration (as opposed to the current 50% criteria). Require automated bi-level controls in intermittently occupied spaces in offices, warehouses, and hotels/motels.
Nonresidential 10	Sidelighting	Require sidelighting (daylighting through windows) for specific occupancy types, including potential changes to the definition of daylit area and requirements for daylighting controls.
Nonresidential 11	Multifamily exhaust fan systems	Require variable speed drive control of exhaust fan systems to maintain efficiently exhaust stack pressure and develop ACM modeling rules.
Nonresidential 12	HVAC Standard Design Specifications	Revise the Standard Design specifications in the ACM manual to require more efficient standard systems.
Nonresidential 13	Single zone VAV	Develop requirements for VAV control of single zone systems using proven technologies.
Nonresidential 14	DDC to Zone level	Require Direct Digital Control (DDC) of HVAC system components at the zone level for new construction and retrofit projects, including development of acceptance requirements for these controls.

Nonresidential 15	Cool roofs	Update reflectance for weathering effects. Consider adding high-slope cool roofs as a prescriptive requirement.
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In addition, the Southern California Edison Company (Edison) will be sponsoring investigation of Demand Responsive devices and protocols consistent with the Demand Response topic area.

Edison also is continuing work begun during the 2005 Standards proceeding to develop a compliance option for "staged-volume fan control." Packaged single-zone rooftop system in the 7-1/2 to 15 ton range are one of the most common HVAC system sold in California. These units commonly have two stages of heating and two stages of cooling. Most efforts to date to reduce the energy consumption of this equipment have been focused on increasing the heating and cooling efficiencies of these units, and while further gains are possible, the gains will be incrementally smaller and relatively expensive. However, little attention has been given to the reducing the energy use of the fans, even though the fans may consume as much or more energy than the compressors on an annual basis. An electronic variable-speed drive (VSD) that stages fan output with the heating/cooling staging can typically cut the annual fan energy by more than half, resulting in an annual efficiency gain of 25% for the HVAC system. For the 2008 Standards, Edison intends to complete prototype development and demonstration of units with staged-volume fan control, and changes to the ACM manual to provide compliance credit for such equipment.

The Contractor will provide technical support to assist the Commission in the review and improvement where necessary of these utility CASE Initiatives, and integration of these proposals into the 2008 Standards. This will include coordination with the utilities for review of the technical work and draft CASE initiative reports prior to public presentation, and integration of CASE initiative conclusions into the Standards, ACM manuals, Joint Appendices, and compliance manuals.

O. Utility Measurement, Assessment and Evaluation Studies

On an ongoing basis, the utilities conduct measurement, assessment and evaluation (MA&E) studies to collect data for improving utility program design and effectiveness. Utility MA&E studies related to codes and standards programs and new construction programs can provide valuable data regarding the energy using characteristics and features of new California buildings, the level of compliance with the existing Standards, and perceptions of key factors in the construction process for how to increase the efficiency of new California buildings.

In the AB 970 (2001 Standards) proceeding and the 2005 Standards proceeding, a database of DOE 2.1 simulations for 800 new nonresidential buildings, which was created as a result of a Nonresidential New Construction MA&E study, was used to estimate the impacts of proposed Nonresidential Standards changes. Although the Commission has historically used a prototype approach to evaluate the impacts of Standards changes for residential buildings, a similar database of new residential buildings was used for comparison purposes to estimate the impacts of proposed Residential Standards changes for the 2005 Standards. The 2008 Standards should attempt to make maximum use of the data and findings of utility MA&E studies.

P. Lighting Improvements

As a part of the 2005 Standards, the Commission adopted significant changes to both residential and nonresidential lighting. The residential lighting standards now require that in kitchens, at least 50% of the watts must come from high efficacy sources. Lighting in bathrooms must be either high efficacy or controlled by a manual-on occupant sensor. Lighting in support areas such as garages, utility rooms, and laundry rooms, as well as lighting in dining areas, bedrooms, and hallways, must be either high efficacy or controlled by a manual-on occupant sensor or dimmer. Exterior lighting must also be high efficacy or controlled by an automatic-on occupant sensor. Definitions for bathrooms and kitchens were also clarified.

For the 2008 Standards, the Commission intends to consider further refinement of the 2005 requirements for bathrooms to require at least one high efficacy light source in bathrooms when all other luminaires are controlled by occupant sensors. In addition to being an energy efficiency measure, this is also a safety feature that ensures that at least one light stays on while the bathroom is occupied if no motion is detected within the preset time. The 2005 Residential Compliance Manual addresses this issue as an advisory note; the 2008 Standards will consider it as a mandatory measure. For support areas, the Commission intends to consider requiring high efficacy luminaires, and removing the controls exception.

The 2005 Standards significantly modified nonresidential lighting requirements. Availability of more efficient lighting technologies allowed the Commission to lower the lighting power densities (LPDs) for many complete building method and area category method categories. New types of uses and function areas were added to the complete building method and area category methods. The tailored method was completely revamped for simplification, facilitating compliance and enforcement of the requirements, closing several loopholes, and lowering general lighting and tailored special allowance LPDs. The 2005 tailored method values for special lighting allowances were derived assuming incandescent lighting sources such MR-16 luminaires. Ceramic metal halide (CMH) luminaires were considered as an alternative to the incandescent sources but were found to be marginally not cost effective. For the 2008 Standards, the Commission intends to reconsider CMH sources for the tailored special lighting allowances to determine if they are more cost effective than incandescent sources.

For the 2008 Standards, the ASHRAE/IES 90.1 LPDs must be compared against the 2005 complete building method and the area category method to determine if there are opportunities for further refinement of the Title 24 LPDs. This analysis must consider new higher efficacy lighting fixtures and the conceptual differences between Title 24 and 90.1 lighting standards. One conceptual difference for example is that Title 24 allows lighting power adjustments for certain lighting controls while 90.1 does not. Also, Title 24 relies on the tailored method for specialized lighting requirements, such as retail, while 90.1 provides special allowances within the space by the usage type of space (roughly equivalent to the Title 24 area category method).

The Commission also intends to consider revising the lighting standards based on lux rather than foot-candles. IESNA guidance documents including the 9th Edition of the Handbook are lux-based. Lux is the SI (International System of Units) measure of illuminance whereas foot-candles is the illuminance measure in the English system of measurement. Title 24 currently uses an imprecise conversion factor of 10 lux per foot-candles. The correct conversion is 10.76 lux per foot-candles. Therefore, the current practice of basing the Standards on foot-candles (with the incorrect conversion) causes an error of about 7.6%, resulting in over-illuminating the space relative to IESNA guidance and the associated waste of energy.

The 2005 outdoor lighting power densities must be revisited for the 2008 cycle. IESNA design guidance documents often recommend more than one illuminance level for the same task. The Commission decided to incorporate the highest illumination levels in all IESNA recommended practices into the lighting models that were used to determine Standards LPDs. This led to LPDs that are perceived to be higher than necessary. For the 2008 Standards, the Commission intends to revisit the LPDs for outdoor lighting to ensure that they represent the latest information from IESNA and are based on sound models.

The use of light emitting diodes (LEDs) is rapidly expanding in the marketplace for a variety of residential, nonresidential, and outdoor lighting applications. The advantages of LEDs include full range dimmability and compatibility with occupant sensors. LEDs, however, generally have not had high enough lumen per watt ratings to qualify for consideration as high efficacy sources under the Standards. Recently, amber light-emitting diodes (LEDs) have surpassed 40 lumens per watt of efficacy, which means that LED luminaires may be considered high efficacy in some applications. LEDs also are being used to provide low energy lighting functions for particular applications, such as a "night light" function for exterior building entrance lighting and hotel bathroom lighting and to add low energy decorative "sparkle" interior luminaires. The Commission intends to consider whether the special characteristics of LEDs should be encouraged for particular applications in the Standards.

PIER has sponsored development of a "smart bathroom fixture" for hotels, motels, and dormitories that is a combination task and night-light with an integrated occupant sensor control. An LED provides night lighting when the bathroom is not occupied, and fluorescent lighting provides full task lighting when occupancy is detected. The Commission intends to consider whether this type of fixture should be required by the 2008 Standards.

The 2005 Standards provide control credits for occupant sensor-controlled multi-level switching that controls fixtures in hallways of hotel/motels, commercial storage areas, and library stacks. Recently, PIER sponsored the development of a "bi-level stairwell lighting fixture" equipped with an occupant sensor. The fixture provides two lighting levels, a brighter level for when the stairs are occupied and a low (standby) level when the stairs are unoccupied. The Commission intends to consider requiring this type of occupant control for stairwells in the 2008 Standards.

The 2005 Standards, for the first time, included prescriptive requirements for skylights in spaces larger than 25,000 square feet and ceiling heights greater than 15 feet. A 2008 PG&E CASE initiative will explore the possibility of extending this requirement to buildings with smaller areas and lower ceilings. Another PG&E case initiative will consider prescriptive requirements for sidelighting (daylighting from windows). A PIER project also has been investigating self-calibrating daylighting sensors for these applications. For the 2008 Standards, the Commission intends to consider all of these daylighting approaches.

The Contractor will provide technical support for the justification and documentation of Standards and ACM changes as necessary for all of these lighting topic areas.

Q. High Efficiency Cooling Equipment for Hot and Dry Climates

Currently PIER is sponsoring two projects aimed at mitigating peak air conditioning demand in the state: Hot and Dry Air Conditioning (HDAC) and Advanced Roof Top Units (ARTU). The goals of HDAC include:

- developing cost effective 3 and 5 ton A/C units for hot and dry climate applications to reduce demand by 15% to 25% and reduce operating costs by 10% to 25%,
- producing A/C design guideline specifications for HDAC,
- investigating various control strategies and building interactions to reduce electrical peaks.

These high efficiency goals for HDACs are achieved through the following technical approaches:

- Produces sensible capacity only (except when indoor dewpoint exceeds 57 to 60°F)
- Provides high sensible EER) (combination of high sensible heat ratio coil and high EER)
- Reduced sensitivity to high external static pressure
- Reduced sensitivity to incorrect refrigerant charge

HDAC hardware advances to achieve these goals include the following:

- High efficiency heat exchangers
- Increased heat transfer area
- Improved overall coefficient of heat transfer
- Low temperature differential
- High efficiency compressor with downsized capacity
- Low superheat with electronic expansion valve
- High efficiency fans, motors, and air passages within the cabinet
- Optimized evaporator airflow
- Design airflow: ~ 340 cfm per ton @ 0.5"WC
- Possibly variable air volume
- Condenser airflow optimized to combined efficiency of all components

The goals of ARTU are to produce a prototype unit that:

- provides continuous ventilation during building occupancy periods to meet current ventilation standards, thereby improving indoor air quality ,
- has improved reliability, thereby requiring less maintenance, and
- reduces energy use through avoided operational degradation.

Improved ARTU features include these:

- Improved Outside Air and Fan control
- Improved economizer reliability
- On-board fault detection and diagnostics
- Data logging capabilities
- Communication with building supervisory control system
- Fault-tolerant design
- Low voltage detection and protection
- Tolerant of improper refrigerant charge

Another PIER project is evaluating Indirect-Direct Evaporative Coolers (IDEC) for hot/dry climates. IDEC takes advantage of low dew point temperatures in hot and dry climates to provide supply air below wetbulb temperatures. In hot and dry climate zones, IDEC can cool

buildings more efficiently than conventional air conditioners with compressors. Moreover, IDEC avoids some of the moisture and comfort problems associated with swap coolers, increasing the chances of acceptability by end users.

For the 2008 Standards, the Contractor will consider compliance options for the HDAC, ARTU, and IDEC cooling equipment.