Upgrading Title 24: Residential and Nonresidential Building Energy Standards Improvements in California

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ABSTRACT

Traditionally, most of the changes to California's energy standards were generated, vetted and proposed by Energy Commission staff or their consultants. Beginning in 2000, however, the Pacific Gas and Electric Company (PG&E) has used public benefits and energy program monies to take an active role in this process.

This involvement has taken the form of Codes and Standards Enhancement (CASE) Initiatives. A CASE Initiative research project, and its support document, results in a detailed and well defended code change proposal that is submitted to the Energy Commission for consideration and ultimate adoption into the state's energy standards.

The source of many of the CASE Initiatives has been PG&E's energy efficiency program experience. These programs have helped to introduce efficient products and practices into the marketplace, build their support networks, and bring down their costs. When they are "ready for prime time," they can be adopted into standards, making them a permanent part of standard practice for new building construction.

This paper presents examples of 2001 PG&E CASE Initiatives for both residential and nonresidential building. Included are proposals for time dependent valuation, residential lighting efficiency, improved water heating efficiency, multifamily building standards, nonresidential bi-level lighting controls, chillers and cooling towers, night ventilation, and others. These are code change ideas that will save energy in California, and which could be widely applicable in other state and federal codes.

Background

California has had energy efficiency standards for buildings (Title 24 (CEC 2001)) since 1978. They have influenced the design of nearly 100,000 new homes per year, and over 150 million square feet annually of nonresidential construction (Quantum 2001). In the most recent round of Title 24 revisions, known as the AB 970 proceedings (CEC 2001), the projected ten year savings were 7200 gWh, 1994 MW and 34 M Therms for residential buildings, and 3964 gWh, 279 MW and 25 M Therms for nonresidential buildings (HMG 2001). We expect to achieve comparable, additional savings in the 2005 update to Title 24. While it may be true that California is unique among states with its large size, combined with its ability to establish statewide energy efficiency standards, this record of achievement nevertheless demonstrates that standards can be a very important tool for producing economic and environmental benefits.

Concurrent with the implementation of efficiency standards, California has had very active voluntary energy efficiency programs across the state, most of them administered by utility companies. The California Public Utilities Commission (CPUC) established a system of public goods charges (PGC), whereby the utilities collected monies from ratepayers to be used for promoting voluntary energy efficiency that exceeded the minimum state standards. Over time, these programs were characterized as conservation, then efficiency, then demand side management, then market transformation, then back again to energy efficiency programs. But whatever the descriptor, they have had the effect of encouraging and accelerating the adoption of new energy efficiency equipment and design practices.

Beginning in 1999, these two processes – minimum efficiency standards and voluntary high efficiency programs – began to coalesce into a more integrated paradigm of market transformation. Pacific Gas and Electric Co. (PG&E) allocated a portion of its energy efficiency program funds for participating in the process of updating and enhancing the Title 24 Standards. Many of the ideas it developed for code change proposals derived from efficiency materials and methods that were first encouraged by the voluntary programs. As they became more widely accepted in the marketplace, they became candidates for inclusion in Title 24, which codifies standard good practice for cost effective energy efficiency.

Historically, the process for updating Title 24 was driven primarily by the staff of the California Energy Commission (CEC), with support from hired consultants and advice from voluntary advisors. The burden and expense of demonstrating the cost effectiveness and market readiness of new Title 24 requirements fell to the CEC staff, and depended on the political will of the state to provide the resources for keeping Title 24 up-to-date. During the most of the 90's, the CEC was resource constrained and limited itself to only minor updates to the Title 24 Standards. Utility involvement in Title 24 during this period was limited to a few observers and advocacy of a few modest improvements to the Standards.

With the coming of the energy emergencies of 1999 and 2000, there was new political will, new financial resources, and a legislative mandate (AB 970) for the CEC to make rapid improvements to Title 24. At the same time, PG&E was ready with a number of significant code change proposals which had been developed by its staff and consultants using PGC funds. Many of those proposals were adopted into the Standards, which took effect in June, 2001. (Stone 2002). This process changed the role of the CEC staff for many of these code changes: instead of originator and developer of code change proposals, the staff became the arbiter and vetting agent who chose and approved proposals developed by the utilities and other parties. For their part, PG&E was able to carry many of their voluntary efficiency efforts to their logical conclusion: adoption as part of the state's minimum efficiency standards. This locked in long term energy savings, and ended the need for rebates, technical assistance and other forms of incentives for those measures.

Following these successes, PG&E is continuing its involvement in the latest round of updates to Title 24, which are due for adoption in 2004, to take effect in 2005. The following sections describe how code change proposals are developed, and what changes are being proposed for inclusion into the standards.[1]

[1] A similar process is taking place with California's Appliance Efficiency Standards (Title 20), which govern equipment that may be sold. (reference Pope ACEEE 2002 paper).

CASE Initiative Process

In developing its proposals for enhancements to Title 24, PG&E uses a process it calls Codes and Standards Enhancement (CASE) initiatives. Each CASE initiative represents a discrete and well-thought-out proposal to change the Title 24 Standards. The CASE initiatives are prepared by experienced energy consultants working under the direction of PG&E Codes and Standards program staff. Other California utilities and stakeholders also participate in this process, either as collaborators or as developers of their own CASE initiatives.

Criteria for CASE Selection

The process begins with the selection of CASE ideas from among a long list of ideas. This list is generated in brainstorming sessions with PG&E staff, their consultants, outside stakeholders, and CEC staff. Ideas may range from something as simple as developing a credit for an optional efficiency measure, to something as complex as a change to the requirements for overall building efficiency. The ideas are then ranked according to the following criteria:

1. **Technical Feasibility** – are there any technical problems that limit the effectiveness of the idea as a code requirement, which can cause problems for building operators, or that lead to incompatibilities with other building systems?
2. **Market Readiness** – is there a sufficiently large market and diversity of supply sources in the market so that builders can procure, at a reasonable cost and without special ordering, the equipment or services needed to meet the requirement; can the market meet the demand that the new requirement will create?
3. **Economic Benefits** – is the requirement likely to be cost effective on a life cycle basis, as required by the Standards; are there any other economic benefits to building owners, builders, manufacturers?
4. **Political Feasibility** – is the requirement likely to encounter vigorous political opposition, and if so from whom; is it likely that the concerns of the opponents can be addressed?
5. **Level of Effort** – how much new research and analysis work will be required to develop the CASE initiative; can the work be done within the available timeframe; are there sufficient resources in the project budget to support the needed work?
6. **Activities by Others** – is the idea already being addressed by the CEC staff or by other groups; can we leave it to them to address; can we coordinate our efforts with theirs to avoid duplication; will the idea be given serious consideration by the CEC?

The list and rankings are discussed, and judgments are made as to which ideas will be selected for further development as CASE initiatives. The successful ideas are then assigned to members of the consultant team who have special expertise and experience in the subject.

Development Process for CASE Initiative Proposals

Each CASE initiative entails a serious amount of research and analysis, and the type of effort required depends on the nature of the proposal. The researcher, of course, has a good idea of the issues and information needs at the outset, because these have been discussed during the selection process. Generally, the process starts with a literature review to ensure that all pertinent, published information about the proposed code measure is accounted for. This could include experience with similar code requirements in other jurisdictions (ASHRAE, other states, model codes, etc.), experience with the measure in market transformation programs, technical reports on applications or buildings which have employed the measure, and product application literature from manufacturers. In addition, designers and application engineers, code officials, manufacturers representatives and others knowledgeable about the measure are consulted and, if possible, recruited to an advisory committee. Concurrently, data on the cost of the measure, its availability in the market, and its likely energy savings are developed. Information about any possible negative consequences of the measure are also sought. In short, the researcher attempts to develop a complete picture of whether or not the measure is "ready for prime time", and so adoptable as part of the Title 24 Standards. As this information develops, the researcher continues discussions with potentially affected stakeholders and with the CEC staff. This is a two way discussion, with the stakeholders offering criticism and advice, and the researchers providing education and data about the proposed measure.

CASE Initiative Report

When the information gathering and analysis are complete, the researcher prepares a CASE Initiative Report for formal presentation to the CEC and the public. This document includes the chapters described below.

Description. Describes the proposed measure or change and how it would apply to buildings regulated by the California Building Energy Efficiency Standards. Describes the building types or systems where the change/measure would most likely apply.

Benefits. Describes the benefits of the change/measure, especially energy savings and electricity peak demand reduction. Explains why the measure is good for the building owner or occupant. If possible, it identifies other benefits, such as comfort, reduced maintenance costs, environmental benefits, indoor air quality benefits, health and safety benefits, productivity, and increased property valuation.

Environmental impact. Discusses whether the change/measure has any potential adverse environmental impacts, increases water consumption, has any impact on indoor air quality or otherwise affect indoor environmental quality, affects atmospheric emissions (including ozone depleting gases), has environmental or energy impacts associated with material extraction, manufacture, packaging, shipping to the job site, installation at the job site, or other activities associated with implementing the measure in buildings, etc.

Type of change. Describes how the measure or change would be addressed in the California standards, e.g. is the proposed change likely to be a mandatory measure, prescriptive requirement, or compliance option, or whether it would change the way that tradeoff calculations are made. Discusses whether the proposed change would modify or expand the scope of the standards, or if, as result of the change, the standards would address new issues or provide requirements for systems or equipment, not previously regulated? Also identifies the standards documents (Standards, alternative calculation methods, manuals, compliance forms, etc.) that would need to be modified in order to implement the proposed change.

Measure availability and cost. Identifies the principal manufacturers/suppliers who make the measure (product, technology, design strategy or installation technique), their methods of distribution, and whether the measure is readily available from multiple providers. Discusses the current ability of the market to supply the measure in response to the possible standards change and the potential for the market to ramp up to meet demand associated with the possible standards change. Identifies competing products and discusses the likely market impacts of increased use of the measure. Also, for purposes of assessing measure cost effectiveness, defines the baseline condition and what would the measure be compared to, e.g. the current standards or common practice? Includes comments on both initial cost and maintenance costs, and whether performance verification or commissioning costs would be significant?

Useful life, persistence and maintenance. Describes the life, frequency of replacement, and maintenance procedures related to the measure, and projects how long the energy savings related to the measure will persist. Explains if persistence is related to performance verification, proper maintenance and/or commissioning, and how the energy performance, useful life and persistence of savings would be affected by performance verification or commissioning. If there are issues related to persistence, discusses how they could be addressed.

Cost effectiveness. If the change is a mandatory measure or prescriptive requirement, then it is necessary to demonstrate cost effectiveness. (While cost effectiveness justification is optional for compliance options, it helps make the case for their consideration.) Cost effectiveness calculation guidelines are published by CEC (CEC 2002).

Analysis tools. Describes what tools would be needed to quantify energy savings and peak electricity demand reductions, and whether these benefits can be quantified using the current reference method and what enhancements to the reference method would be needed, if any.

Relationship to other measures. Identifies any other measures that would be impacted by this change, and explains the nature of the impact.

Draft standards language. Proposes formal Standards language for the measure, using the same numbering and format used in the Standards. When amending existing language, uses underline/strikeout to show the changes. Proposed language is annotated with sufficient explanatory material to make it clear what is proposed.

Bibliography and other research. Lists and describes each of the research studies, reports, and personal communications that provide background on the proposed change/measure. Summarizes research that is underway, which addresses the measure/change. Indicates if data or information will be produced in time to be used in this update of the Standards. Identifies all resources that have been pursued to further this measure. Identifies all "experts" that were involved in further developing the change, all research and analysis reports and documents that were reviewed, all industry standards that were consulted (e.g., ASTM, UL, ASHRAE test procedures, etc.).

CEC Process for Code Change Proposals

The CASE initiative reports are presented formally in a public workshop, where they are discussed and questions are asked for clarification or to request further data/analysis. Following the workshop, CEC staff and other stakeholders meet with the CASE initiative authors to further refine the proposal, answer questions, make modifications, coordinate interaction with competing or complementary proposals, etc. The researchers generally do whatever it takes to make the proposal acceptable and defensible, to resolve objections from staff and stakeholders, and to move the proposal through to adoption.

The following sections describe the most significant CASE Initiatives prepared by/for PG&E for inclusion in the Title 24 Standards update process in 2002. The successful proposals will be incorporated into the next revision of the Standards, to be adopted in 2004 and take effect in 2005.

Time Dependent Valuation Proposals

Perhaps the most fundamental change proposed as a CASE initiative is Time Dependent Valuation for the energy standards. If adopted, it will change the way that the energy savings of all future Title 24 measures are valued.

The Title 24 energy standards are derived from calculations of energy savings for the various energy efficiency measures they require. They also allow users to make trade-offs between measures, using the computer analysis methods of the performance approach. Historically, within the Title 24 methodology, the value of measure savings has been calculated on the basis of a "flat" energy cost, which does not vary by season, or by day-of-the-week, or by time-of-day.

The idea of time dependent valuation (TDV) is that measure savings should be valued differently at different times, to better reflect the actual costs to users, to the utility system, and to society. For example, the savings of an energy measure that is very efficient during hot summer weekday afternoons would be valued more highly than a measure that offers savings only during off-peak conditions. This kind of savings valuation reflects the realities of the energy market, where high system demand on summer afternoons drives electricity prices much higher than during, say, night time hours in mild weather. TDV would also value electricity, natural gas and propane energy savings in proportion to their actual, relative cost savings. Thus, TDV promises a more realistic way to value energy savings than the traditional flat valuation scheme of the Title 24 Standards.

The TDV project has developed a rational method for deriving time dependent valuations for energy savings, and proposes that this method be adopted as the basis for Title

24 energy savings calculations. Doing so would allow the Title 24 efficiency standards to provide more realistic signals to building designers, encouraging them to design buildings that perform better during periods of high energy cost. Over time, as the proportion of buildings designed in response to these signals become a significant part of the population, the overall energy system in California should see lower peak demand and lower costs than it otherwise would have seen under the old Title 24.

There are two major components to the TDV proposal:

TDV Economics

The energy savings valuation scheme under TDV is developed using principles familiar to utility economists. The methodology uses CEC forecasts for statewide annual retail rates (electricity and natural gas) over the next 30 years, utility transmission and distribution costs by service territory, hourly and temperature dependent load shapes for these components by climate zone, and overall utility revenue requirements by utility. The methodology produces a series of 8760 hourly values of energy, on a life cycle present value basis. When used to evaluate building performance trade-offs, the hourly energy demand of a base case and a proposed building design are each multiplied by the hourly TDV factors. These are summed and compared: if the proposed design's annual energy valuation is not greater than the base case energy valuation, then the building is deemed to comply with Title 24. Energy measures in the proposed design, which save more energy during the peak periods, are more highly valued and so are more effective at helping the building to achieve compliance.

Figure 1 compares the TDV values for a typical summer weekly time period with the original flat valuation of Title 24; it shows the time of day variation in the TDV values.

Figure 1. TDV Hourly Shape Compared to Title 24 Flat Valuation

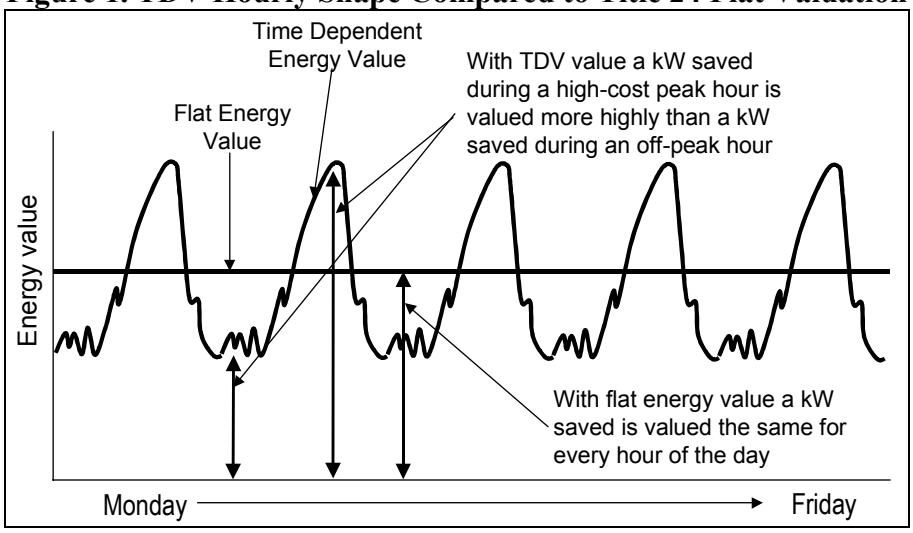
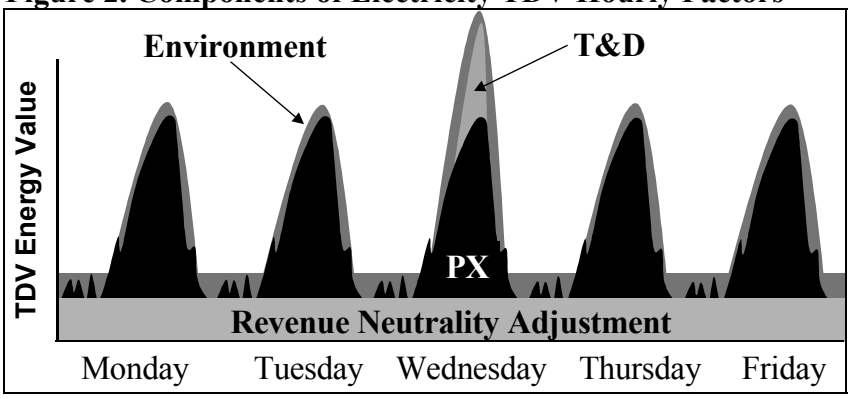


Figure 2 shows, for a typical, hot, summer work week, how the components of the TDV economics methodology are combined to derive the ultimate hourly TDV factors. The generation component (PX) reflects hourly, daily and monthly variations in the cost of generation statewide, derived from historical patterns experienced by the power exchange.

The transmission and distribution component (T&D) reflects the system peak-related costs to deliver power, derived as a function of peak temperatures in each climate zone and only allocated to the hottest hours of the year. The revenue neutrality adjustment reflects all of the other costs to the utility system, such as meter reading, taxes, billing, fixed system costs, etc. that go into the overall revenue requirements for the utilities. The environmental externalities component (Environment) is derived from the market prices for CO_2 and NO_x offsets. Similar curves were derived for natural gas and for propane, but these do not vary hourly, only by month and season.

Figure 2. Components of Electricity TDV Hourly Factors



TDV Engineering

In order for TDV to accurately determine hourly energy savings values, the computer modeling tools used for Title 24 compliance must incorporate accurate hourly simulation algorithms. This requires upgrading some of the compliance tools. The most obvious example of the needed upgrades is with the residential computer program, which historically calculated an hourly air conditioning load but used only an annual efficiency factor to estimate air conditioning energy usage. Under TDV, an hourly air conditioning equipment model has been developed to work with the compliance simulation tool. This new capability allows Title 24, for the first time, to distinguish the performance differences between air conditioners that perform well during hot weather conditions and those that do not. This, in turn, provides a mechanism for Title 24 to award performance credit to the higher efficiency air conditioners, and so to encourage their adoption in the market. Over the long run, Title 24 will help to reduce system demand due to peak summer cooling loads.

Similar enhancements to the computer simulation tools were developed for water heating, for cool roofs, and for attic/duct insulation measures, all of which incorporate hourly energy usage models.

There is not space here to more fully describe the details of TDV and how it was developed. That information is available on the TDV project web site (HMG 2002).

Residential Title 24 Proposals

The residential Title 24 Standards in California are already stringent enough that they are approaching the limits of cost effective measures that reasonably can be required. This arena attracts sophisticated interveners, and it requires a high standard of proof before changes are incorporated into code. There is also a great deal of attention paid to ensuring good enforcement, due to the large number of small construction projects that characterize the residential market. The CASE initiatives for the residential standards emphasize some modest extensions of the stringency of the standards, along with ways to improve enforceability and compliance. There is also attention to the multifamily sector, which has been treated as a hybrid between residential and nonresidential sectors in the standards, but which has many unique characteristics of its own.

Nonresidential Title 24 Proposals

The nonresidential standards in California do not attract as much political attention as do the residential standards, and they are technically more complex due to the larger size of the buildings and their systems. The PG&E nonresidential CASE initiatives address a number of areas which are ripe for either updating or enhancing stringency requirements.

Table 1. Residential Title 24 CASE Initiatives[2]

Topic	Description
Hardwired Lighting	This proposal involves modifying the current mandatory measures for residential lighting. The target is to 1) improve enforcement 2) expand scope of coverage, 3) promote high efficacy lighting throughout the home (typically fluorescents) and 4) provide reasonable exemptions from high efficacy lighting for specific rooms. The proposal requires 50% of kitchen installed lighting wattage to be high efficacy. Bathrooms, laundries, utility rooms, garages and outdoor lighting are required to use high efficacy lighting, unless a motion sensor is installed to control the lighting. Recessed, track and pendant fixtures are required to be high efficacy lighting, unless controlled by a dimmer. The result will be more high efficacy hardwired fixtures of appropriate types installed throughout most areas of the home. Plug-in fixtures are not governed by Title 24.
DHW Based on TDV	This proposal provides a revised, hourly water heating calculation methodology compatible with the time dependent valuation (TDV – see above) of energy efficiency. The result affects the water heating budgets; and particularly effects water heating that uses electricity as primary fuel. It allows more accurate treatment of water heating energy, and more realistic credit for improvements in efficiency. Also, this is a necessary adjunct to the adoption of TDV in Title 24.
Multifamily Water Heating	This proposal revises the water heating assumptions and calculation methods to more accurately reflect typical multifamily construction. Currently there is a large undeserved energy credit for multifamily buildings, because Title 24 assumes individual water heaters for each unit; typical practice often uses central water heating systems, so these buildings get credit for doing what would be done anyway. Common features in multifamily water heating, especially pump-driven circulation loops and their controls, will be treated explicitly in the standards.
Existing Dwellings	Proposal encourages duct sealing at the time of HVAC system replacement, as well as window improvements (similar to prescriptive levels) at time of window replacement. For the first time this will require efficiency improvements in the large existing home market.
Advanced Evaporative Cooling	Project proposes an Exceptional Method Application for an energy compliance tradeoff which would recognize the use of advanced evaporative cooling technologies in the home by increasing the available tradeoff credit. This may not save energy in the short run, but it will encourage greater market acceptance of the technology and, in the future, can become a requirement rather than an option for compliance.
Night Ventilation Cooling	This topic proposes a new compliance option: to recognize fully automated night ventilation cooling through existing mechanical systems. Also changes the base case assumption of night ventilation practice, which is currently assumed to be perfectly temperature dependent. Proposal demonstrates large savings potential and near readiness of the marketplace. In the future, this trade-off option could become a prescriptive requirement
Standards Implementation Process	This topic improves the value of the standards by reviewing compliance forms and processes, and proposing changes that would help increase the level of standards enforcement in the field. This proposal recognizes that good enforcement is necessary to realizing savings potential of the standards.

[2] This is not an exhaustive list of residential topics proposed by all stakeholders; rather it is the list of topics supported by PG&E's Codes & Standards program for PY2002. Full details on them are available on the project web site (HMG, 2002)

Table 2. Nonresidential Title 24 CASE Initiatives[3]

Topic	Description
Cooling Towers	Proposal refines allowed limits and settings for use with cooling towers. It would save energy through better optimization of cooling tower designs, thus reducing cooling energy and peak load. Proposal is coupled with limitations on the use of air cooled condensers for systems that compete with water cooled condensing.
Automatic Bi-Level Lighting Controls	Proposal would at first encourage, and in the future possibly require, the use of automatic bi-level switching in some commercial occupancies, such as hallways, corridors and storage areas. This measure turns off 50% or more of the lighting, under occupancy sensor control, when spaces are unoccupied. Proposal can be extended to cover intermittently occupied unconditioned spaces (parking garages, warehouses) and outdoor lighting.
Modular Classroom Efficiency	Proposal defines a discrete set of cost effect measures by climate zone for the modular classroom efficiency market, saving both gas and electricity on and off peak. Cost-effectiveness calculations show that tightening the standards is justified. Proposal also addresses ways to improve the enforcement and compliance process for these manufactured buildings, which are regulated by the California Office of the State Architect.
Duct Tightness	This proposal encourages the reduction of duct leakage in light commercial buildings, which is greater than leakage in residential buildings. By designing an appropriate compliance credit, this measure would help encourage better duct design, thereby reducing heating and cooling loads. Proposal is limited to fixing the erroneous assumptions in the current code, leaving duct tightening as a credit rather than adding it to the base building.
Skylights Controls, PAF's, Daylighting Requirements	Proposes ways to minimize the use of electric light under skylit areas and encourage the use of daylighting with skylights, which reduces electric load during the daytime hours. Includes proposal for requiring automatic controls in skylit spaces (they have been optional to date), and the requirement of skylights (base case assumption) in certain types of commercial buildings (which have also been optional).
Existing Building Efficiencies	This proposal sets duct requirements for existing buildings, triggered by issuance of a building permit to replace, add or modify HVAC systems or to replace windows. This proposal represents an initial attempt to affect energy efficiency in the large existing light commercial market.
HVAC Equipment Efficiencies	This proposal provides updated efficiency tables for large, non-NAECA cooling equipment (greater than 20 Tons). Incremental cost reductions and higher energy costs have made this equipment cost effective. The effect of this change would be to increase cooling efficiencies, thereby reducing cooling usage and peak load.

[3] This is not an exhaustive list of nonresidential topics; rather it is the list of topics supported by PG&E's Codes & Standards program for PY2002. Full details on them are available on the project web site (HMG, 2002)

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