2008 California Codes and Standards Progress: Expanding and Consolidating Efficiency Gains

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ABSTRACT

This paper discusses the cycle of expansion and consolidation of energy efficiency measures in the California Title 24 building energy efficiency standards by a motivated state government within the construct of market transformation and diffusion of innovations. The 2005 version of Title 24 regulated many new areas of building energy use for the first time including: residential lighting, outdoor lighting, sign lighting, unconditioned buildings, minimum required skylight areas, mandatory daylighting controls, and acceptance testing of HVAC and lighting controls. The economic and energy trade-off basis was also revised with the introduction of Time Dependent Valuation (TDV). Not surprisingly, a fairly conservative approach was taken when regulating these areas for the first time. This paper discusses the development of code change proposals for the 2008 Title 24 Standards that consolidate the gains from the 2005 Standards. These proposals for the 2008 Standards are based upon new information, including the building market response to the 2005 Standards. Examples are given of how market research and voluntary programs helped develop industry support of increased regulation. Estimates of the statewide energy and peak demand impacts from each of the measures are also detailed.

Background

Electricity consumption in California is predicted to increase between 1.2% and 1.5% annually or approximately 4 GWh/yr. With increasing use of air conditioning, peak demand is expected to grow at an even faster rate, between 1.4% and 1.75% per annum or approximately 1,000 MW per year. Even though there are more plants permitted than under construction, construction of new power plants has not kept up with increasing demand and retiring of older plants. California has developed an Integrated Energy Policy that addresses the balance between electricity demand and supply, and energy efficiency plays a leading role. (CEC 2005)

In 2003, California's lead energy agencies established an energy procurement "loading order" policy that requires that the electrical energy and demand requirements are met first with energy efficiency and demand response, then with renewable and distributed generation electrical supply before resorting to fossil-fueled generation. (2003 CEC, CPUC & CPA). This policy was enacted into law in 2005 with the passage of SB 1037[1], "*This bill would require the [Public Utilities] commission, in consultation with the Energy Commission, to identify all potentially achievable cost-effective electricity efficiency savings and to establish efficiency targets for an electrical corporation to achieve pursuant to its procurement plan. The bill would require that an electrical corporation's procurement plan include a showing that the electrical corporation will first meet its unmet resource needs through all available energy efficiency and*

[1] SB 1037 (Kehoe) Chapter 366, Statutes of 2005

demand reduction resources that are cost effective, reliable, and feasible." Of the various energy efficiency opportunities, the California Integrated Energy Policy Report recognizes that "California's building and appliance standards are the state's most cost-effective efficiency measures." (CEC 2005) Thus, building codes and appliance standards are well established in California energy policy as the "first line of defense" (lowest cost resource) for meeting California's energy and electrical demand needs. The California Investor Owned Utilities (IOUs) have developed Codes and Standards (C&S) programs to accelerate the development and implementation of new energy codes.

Market Transformation and Diffusion Theory

California's energy policy clearly seeks to change or transform energy demands. For the buildings sector this is a function of the characteristics of homes and buildings, the equipment in these spaces, how they are assembled, installed, controlled and operated. From a policy point of view, making these changes on a statewide level can be considered as transforming markets or aggregations of manufacturers, installers, and occupants respectively. Under a market transformation model, the ideal market would be substantially more energy efficient except for a number of market barriers which are spelled out in (Eto et al. 1996) and numerous other market transformation studies.

Market transformation can be considered a process of removing these barriers and putting into place market mechanisms that, to paraphrase Albert Einstein, "make the good easy and the bad difficult."[2] As an example, a flat or constant cost of electricity does not give the correct market signal to the consumer that operating their dryer on a hot summer afternoon is extremely expensive to society as a whole. Replacing the flat electricity rate with a critical peak pricing rate (which might increase the cost of electricity to 10+ times the normal rate during peak events) and communicating a demand response signal into the home makes it more likely that the customer will choose to do their laundry at night when it is cheaper for society and themselves.

A particularly intractable barrier to energy efficiency are split incentives. Split incentives occur when the person who is capable of investing in a given energy efficient feature has no financial incentive to do so. Examples of this are the landlords who do not pay utility bills. Similarly their tenants, who do not own the building and who will not be in the building long enough to recoup the investment cost from utility bill savings, also have no incentive to invest in energy efficiency. Energy codes cut through this Gordian knot of split incentives by requiring the landlord to install cost-effective energy efficiency measures. The landlord is able to increase their rent to cover the cost of a more expensive rental unit, as all landlords have the increased cost of the efficiency measure. The renter can afford a higher rent, as their utility costs have decreased more than the amortized incremental cost of the efficiency measure.

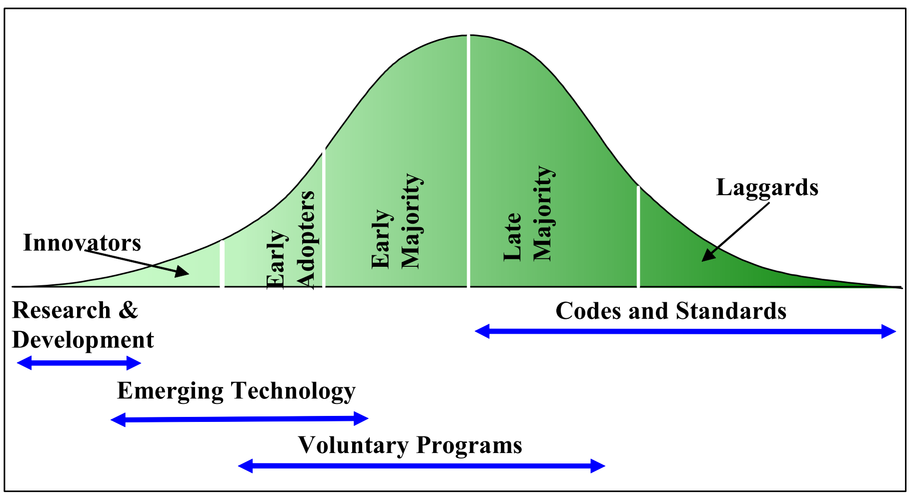
As appealing as energy efficiency code requirements might be from a cost-effectiveness and program overhead point of view, energy code requirements are a "blunt instrument" and have to be applied with considerable discretion. Energy code requirements are the legal minimums in energy efficiency and thus are expected to be well vetted for safety, reliability, availability, broad applicability, non-proprietary, compatible with other building codes, compatible with design and installation practice, cost-effective and environmentally responsible.

[2] Albert Einstein in a private letter sent to Le Corbusier in 1946 and quoted in Le Corbusier's book, the Modulor, see (Ostwald 2001)

Given this long list of caveats, it should not be surprising that new technologies are rarely energy code requirements. Many of these features are developed over the course of years through the discipline of the marketplace that rejects unreliable or overly expensive equipment. Nonetheless there are numerous activities that can hasten the emergence of an energy efficient technology from concept into the energy codes.

The constellation of energy efficiency measures varies from well established (wall insulation, T-8 lamps) to the cutting edge (automated HVAC diagnostics, displacement ventilation) and everything in between. Even the well-established measures started out as innovative ideas and, if satisfying the demands of the marketplace, they are gradually accepted by various segments of the population. Rogers (2003) has segmented the population in terms of their receptivity to innovation. Figure 1 illustrates this concept, where the market for energy efficiency can be segmented in terms of behaviors that embrace new technology from "Innovators" to "Laggards." How far a particular product has penetrated into the marketplace is a reflection not only of the people using the devices, but also the ability of the technology to address the broad needs of the marketplace and to overcome market barriers to its wider acceptance. It should also be recognized that the behaviors described as "innovators" to "laggards" reflect as much market conditions as it does a mindset to embrace new technology.

Figure 1. Market Segments and Diffusion of Energy Efficiency Innovations[3]



At the end of an R&D program, there may be the nucleus or idea for a new product, but also an expectation that investors and/or industry will take on the responsibility of the next steps to commercialize the product. However, this is often a very difficult and uncertain task. Many new products are introduced, but few survive the initial demands of the marketplace.

When a successful product becomes commercially available, there tends to be an ever growing level of support for each step of introduction into the market. The first small step might be assisted by one of the emerging technology (ET) programs run by the California investor owned utilities. These ET programs identify and support technologies or practices that are promising, but have yet to make a significant dent into the market. Oftentimes, these ET programs target early adopters who will provide a case study site where the technology can be

[3] Illustration based upon Figure 7-3"Adopter Categorization on the Basis of Innovativeness" in Rogers (2003).

tested under field conditions. These case studies help identify final production and application problems, provide objective data for marketing materials, and a small initial market for the product while production ramps up.

Once the initial problems have been solved and feasibility of a new energy efficiency product has been demonstrated, the market is larger and public funds to support expansion of the market are likely to grow much larger. At this point, large incentive-based programs are often targeted towards the market as a whole to purchase energy efficiency resources, increasing demand for the product and helping to increase production. If the product is seen as cost effective by the market, it may become standard practice without further support. If there are split incentives or other structural market barriers, it may require continued program support or a targeted market transformation program to help it become standard practice.

Once the technology has moved through all these stages, has been shown to save energy reliably and cost-effectively and does not cause any significant disruptions to other building functions (visibility, acoustics, indoor air quality, aesthetics etc.), then it may become a candidate for inclusion into the energy codes. In general, the purpose of the energy codes is simply to eliminate the worst building design practices of the "Laggards" in favor of the standard practices of the majority, rather than to encourage the best practices of the "Innovators" before they have become mainstream.

For a measure to be incorporated into the building efficiency standards, it must pass a number of economic and feasibility tests. Thus, many of the code-readiness questions related to market acceptance, pricing, and feasibility render the newest, most innovative technologies unlikely candidates for inclusion into the building energy efficiency standards. In general, technologies or design practices that are considered for inclusion into energy codes already have a significant market position, as well as a track record of reliable energy savings and known interactions with other building components. In some cases a significant amount of market research is required to make the case for a given measure's inclusion into the Standards.

2005 CA Title 24 Building Efficiency Standards

The California Energy Commission (CEC) is the agency responsible for developing the building efficiency standards. CEC workshops outlining the proposed revisions commenced in the end of 2001 and concluded with adoption in late 2003 and became effective in October of 2005. The process of selecting proposals to pursue and the code change proposal process are described in Mahone et al. (2002).

The proposals that resulted in changes to the Title 24 building energy code are listed in Table 1. The extensive list reflects the high level of institutional support for increased stringency of the energy standards in the wake of the 2000-2001 electricity crisis. This famous episode resulted in the loss of billions of dollars from the state economy directly in terms of electricity overcharges by generators and indirectly by loss of productive capacity by citizens during rolling blackouts. In addition, the cost-effectiveness analysis required for the California building efficiency standards has ensured that the energy efficiency requirements also increase the economic efficiency of the state. The process of vetting energy codes based on cost-effectiveness, and documenting this finding, has helped to maintain institutional support of the building efficiency standards.

Table 1. Key Changes to 2005 Title 24 Building Efficiency Standards

New Residential	New Nonresidential
TDV - value peak demand	TDV - value peak demand
High efficacy hardwired lighting - indoor and outdoor	Minimum skylight area and daylight controls
Duct insulation increased – varies by climate	Cooling towers
Trade-off credit removed for small windows	Demand control ventilation (DCV)
Insulate kitchen hot water piping	VSD on VAV fans and pumps + HVAC controls
Res Alterations	Relocatable classroom envelope and LPD
New fenestration U-factor and SHGC values apply	Duct insulation - R-8 in unconditioned spaces
Duct sealing, testing and HERS sampled verification upon HVAC repair or replacement (hot climates)	Duct sealing for small single zone systems in unconditioned spaces - tested and sampled verification
Mutli-family	Lower lighting power density (LPD)
Trade-off credit removed for central DHW	Cool roof coatings on low slope roofs
Trade-off credit removed for small windows in low-rise	Metal roofs - more insulation
Outdoor Lighting	**Nonresidntial Alterations**
Outdoor lighting allowed LPD by Lighting Zones (LZs)	Duct sealing, testing and verification in uncond. spaces upon HVAC repair or replacement – for small single zone systems
Outdoor signs - LPD or efficient sources	

Expanding the Scope of Title 24

Outdoor lighting. During the California energy crisis, the State Senate passed SB-5X which, in addition to other things, gave the California Energy Commission the authority to regulate outdoor lighting as part of the building efficiency standards. In the past, Title 24 had only regulated the efficacy (the ratio of light produced by a lamp in lumens to the input power in Watts) of light sources but had not regulated the amount of power density of outdoor lighting in parking lots, walkways etc. Other energy codes, most notably, ASHRAE/IESNA 90.1-1999, had regulated the lighting power density in outdoor locations.

The bold innovation in California's new outdoor lighting code was the inclusion of the IESNA[4] lighting zones and a practical way of defining these lighting zones. Both the CIE[5] and IESNA had recommended that outdoor lighting levels be a function of the ambient lighting to account for the role that visual system accommodation plays in overall visibility. These lighting zones from LZ 1 to LZ 4 correspond to areas with least ambient light levels to those with the most. A standard based on lighting zones assures that the maximum power allowance (and to some extent the maximum light levels) are appropriate to the region and the application (CEC 2004a). The CEC Public Interest Energy Research (PIER) program sponsored field research on current outdoor lighting practices that helped inform the development of the outdoor lighting regulations. The boundaries of Lighting Zones are based on U.S. Census Bureau boundaries for urban and rural areas as well as the legal boundaries of wilderness and park areas. Government designated parks, recreation areas and wildlife preserves are considered Lighting Zone 1; areas designated "rural" by the 2000 US Census are Lighting Zone 2; and areas designated "urban" by the 2000 US Census are Lighting Zone 3. Lighting Zone 4 is a special use district (typically high activity retail) that may be adopted by a local government after giving public notice and holding public hearings. (CEC 2004b)

[4] Illuminating Engineering Society of North America
[5] Commission Internationale de'lEclairage or International Commission on Illumination

Sign lighting. Sign lighting was another new area of energy efficiency regulation which was also enabled by SB-5X. Though it made sense to consider regulating sign power with respect to lighting zones, there was not an IESNA recommended practice or design guideline to support lighting zone-based standards for signs. The sign lighting requirements set maximum watts per square feet of sign area for both internally lit filtered signs (such as cabinet signs or channel letter signs) and externally lit signs(such as billboards), but did not regulate unfiltered signs such as neon and LED displays. As an alternate to meeting W/sf requirements, one could also show compliance by using efficient lighting sources such as: electronic ballasts or rare earth barrier coat phosphors for fluorescent lighting, pulse start ceramic metal halide, and high pressure sodium lamps. Other sources that also could be used as an alternative, but without specific efficiency improvements, included LEDs (light emitting diodes), cold cathode and neon lighting.

Skylighting. Skylights and automatic lighting controls that reduce lighting power in response to daylight were prescriptively required in large open spaces (floor space > 25,000 sf and ceiling height > 15 feet). We are not aware of any other energy code requiring daylight apertures for energy savings. This requirement is a dramatic break from how all energy codes have treated skylights in the past. Previously skylights have been seen as an energy liability – their use minimized and their characteristics focused on minimizing transmitted heat and solar gains. But, when electric lights are turned off in response to available daylight, the energy savings exceed the losses (at least in suitable climates like California's). In the 2005 version of Title 24 minimum skylight areas are required along with daylighting controls. However, the code still retains the maximum skylight area limit of 5% of the gross roof area.

The market for skylighting with photocontrols had been developed by several large big box retailers (Wal-Mart and Costco) who had been using skylighting as part of their standard design for several years, as well as an ongoing daylighting incentive program through the IOU statewide *Savings By Design* (SBD) nonresidential new construction efficiency program. The primary participants in the SBD daylighting program were warehouses and retail spaces with open ceilings. There was still a lingering doubt as to whether photocontrols would yield reliable savings, as there were plenty of anecdotes of photocontrols being overridden in spaces sidelit with windows. Southern California Edison had sponsored a study of 33 skylit spaces to evaluate the realized savings from photocontrols. (HMG 2003, McHugh et al. 2004) This study found that 32 out of 33 photocontrol systems were working with an average realized savings that was 98% of the predicted amounts. The PIER program had also sponsored research on the thermal transmittance, solar gain, visible light and photometric characteristics of skylights. (HMG 2004) As a result of all of these activities, the savings from skylighting in large open spaces were well characterized, the building design and construction issues had been resolved and there was a thriving segment of the market using skylighting. All of this made it possible to develop and adopt the new skylighting standards.

Residential lighting. For a long time, the Title 24 Standards have required fluorescent lighting in kitchens and bathrooms. However in the 2005 Title 24 Standards, high efficacy lighting, or lighting with efficacy as high as compact fluorescent lamps (CFLs), would be required in all other areas of the home. In bathrooms and utility rooms, an alternative to CFLs is "manual on" occupancy sensors; in other areas of the home, manual dimmers are allowed in lieu of high efficacy lighting. This is a major change in how homes have been lit over the last century. Even the alternative to high efficacy lighting is a bold move, as it brings automated lighting controls into the home.

Over the last 10 years the utility incentive programs have spent a lot of time and money promoting CFLs as a replacement for the incandescent lamp. Many barriers to the technology had to be overcome, including color quality, flicker, latency at start-up, lamp size etc. CFLs come in two major types: screw-in CFL's with an integral ballast as part of the lamp and hardwired CFL fixtures which contain a separate ballast and pin-base lamps. The advantage of the screw-in CFL is the lower first cost and the ease of upgrading the ballast. The advantage of the hardwired CFL is that, when the lamp burns out, one must continue to use CFLs if the same luminaire is to be used. Though first cost seems like it would be a large determinant of the proposed energy code requirement, in fact the energy savings compared to incandescent lamps are so large that both hardwired CFLs and their screw-in counterparts are cost-effective as compared to incandescent lamps. Hardwired CFLs were ultimately chosen based upon likelihood of persistence.

Time dependent valuation. As described earlier, an established policy objective was not only to save energy but to reduce peak demand which was increasing at a faster rate than electricity consumption. In the past, when developing energy codes or when the building designer was evaluating the trade-offs between various measures in a given building using the building simulation "performance approach," there was not a methodology to give added value to peak demand reduction. To address the time varying costs of electricity, natural gas and propane, Time Dependent Valuation (TDV) factors for each of these energy sources was created on an hour-by-hour basis over the 8,760 hours of the year. In support of this type of valuation, hourly HVAC equipment and duct efficiency models were created in the residential performance model. The combination of TDV and an hourly air conditioner efficiency model has provided an incentive in the new energy code to install high EER [6]air conditioners which are efficient at high temperatures. The voluntary California utility programs have been creating the demand for high EER equipment for a while, as their research found that high SEER[7] air conditioners did not necessarily have high EERs and, as a result, did not perform well during times of high electrical system demand – usually on hot summer afternoons. Thus, the voluntary programs have been basing their incentives on EER not SEER.

Consolidating Savings in the 2005 Standards

Much of the rest of the updated code measures can be characterized as consolidations of existing code measures. Lighting power densities for regulating indoor lighting have been a key feature if Title 24 for many years. The more stringent 2005 lighting power densities are a result of higher efficacy lighting technologies being available for several years in the market place, such as enhanced phosphors and improved fluorescent ballast technology, as well as widespread availability of pulse start metal halide lamps and ballasts.

Of special note is the expanded use of duct sealing, testing and verification for single zone systems. Duct sealing has been prescriptively required in new residential construction since the 2001 Standards. Expanding the requirement for duct sealing to existing homes, and to new

[6] EER - energy efficiency ratio, based on air conditioners tested at 95ºF
[7] SEER - seasonal energy efficiency ratio, based on air conditioners tested at 82ºF (the only rating of small air conditioners required by the Federal appliance efficiency regulations)

and altered nonresidential spaces, should then seem like a natural expansion of scope. However, special accommodations had to be made for ducts that are installed in existing spaces, where a good part of the ducts are not accessible. A single pass/no pass duct leakage fraction was not feasible, as utility duct sealing program experience had shown that, regardless of leakage amount chosen and the care taken to seal ducts, duct leakage occurring at inaccessible areas would result in some systems not meeting the threshold leakage. This code development process was helped immensely by utility retrofit duct sealing programs that had kept track of costs and savings from duct sealing. As a result, feasible code requirements could be developed for duct sealing in existing spaces.

Savings Estimates and Attribution of Savings

The California investor owned utilities' Codes and Standards (C&S) Program has contributed expertise, research, analysis and other kinds of support to the California Energy Commission to support its efforts to develop and adopt energy efficiency standards for appliances (through Title 20 regulations) and for residential and nonresidential buildings (through Title 24 regulations). In the past, no claims of savings were made for the C&S Program, and so no thorough efforts were made to calculate those savings in a way that estimated their effects over time. The C&S programs in the past were seen as "information programs" with no measurable savings and not counted as part of the portfolio of programs contributing towards the specific energy savings goals set by the Public Utilities Commission. Allocating the appropriate amounts of savings to the C&S programs highlights the importance of these programs and places them on equal footing with other programs. Prior to this allocation, more stringent codes were viewed as disincentives for utility efficiency programs. They made it harder for those voluntary programs to meet their savings goals, as the energy codes provided the baseline against which the savings of these programs were compared.

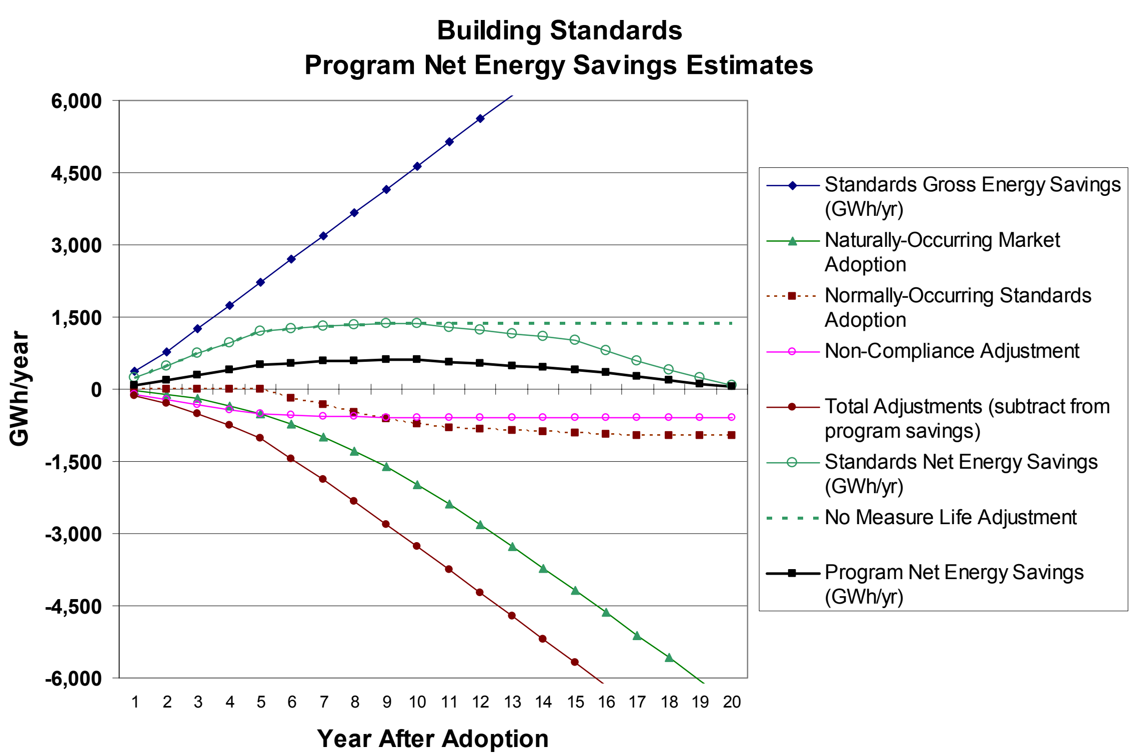
'The first year gross energy and demand savings estimates for the 2005 California building efficiency standards in Table 2 are extracted from *Codes and Standards Program Savings Estimate* (Mahone 2005). Savings estimates were developed for the 13 building standards measures proposed by the C&S Program in its CASE (Codes and Standards Enhancement) reports. (Mahone et al. 2002). The savings estimates for the other measures developed by the CEC and other stakeholders were lumped together and designated as "Composite for Remainder."

Similar to the evaluation of other programs, we are interested in the net savings that resulted from the C&S program relative to a base case of what would have happened without the actions of the program. This "what if" base case situation makes informed estimates about naturally occurring market adoption of higher efficiency technologies without a nudge from energy codes, as well as an estimate from the CEC of how quickly normally occurring standards adoption of the measures would proceed without the input from utility C&S programs. For most of the measures considered here, the natural market adoption period was assumed to be between 10 and 18 years and the naturally occurring standards adoption between 6 and 12 years. Another factor that affects the baseline and the net savings is the non-compliance adjustment which accounts for how many buildings are complying with the energy code. This adjustment, assumed to be 30% in this analysis, accounts for the fact that not all measures are installed even when the code requires them, and so some of the savings are lost.. The gross savings and the adjustments used to yield the net savings are shown in Figure 2 (also from Mahone 2005).

Table 2. 2005 Title 24 Measures and First Year Savings

With CASE Report, Standard Adopted	1st Year Savings (GWh/yr)	1st Year Demand Savings (MW)	1st Year Gas Savings (Mtherms/yr)
Time dependent valuation, Residential	6.70	27.20	
Time dependent valuation, Nonresidential	4.30	18.70	
Res. Hardwired lighting	64.60	2.97	
Duct improvement	5.70	8.50	1.10
Window replacement	6.34	2.40	0.30
Lighting controls under skylights	25.46		
Ducts in existing commercial buildings	9.73	7.36	1.04
Cool roofs	14.60	9.50	
Relocatable classrooms	2.90		
Bi-level lighting control credits	12.14		
Duct testing/sealing in new nonres buildings	8.01		
Cooling tower applications	3.01		
Multifamily Water Heating			1.50
Composite for Remainder	321.54	134.87	3.25
Total	**485.03**	**211.50**	**7.19**

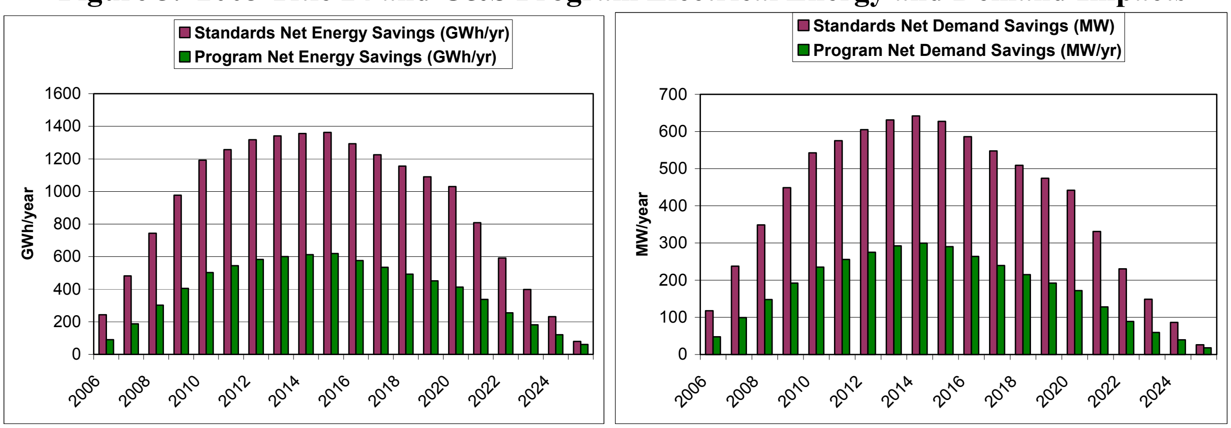
Figure 2. 2005 Title 24 Gross and Net Electrical Energy Savings



The accuracy with which these adjustment factors were derived varies. However, for purposes of allocating savings towards meeting utility efficiency goals, these *ex ante* estimates will be trued up with *ex post* measured savings estimates that will collect the information needed to improve the accuracy of the savings estimate. A positive side-effect of this attention to how much the energy codes are savings is that the designers of the next round of Standards will have input from the measurement and verification studies that indicate problem and success areas with the 2005 Standards that can be corrected or enhanced for the 2008 or 2011 Standards.

In Figure 3, it is easier to see that there are two net savings numbers. The large set of bars over time are the net statewide savings from the 2005 Standards as a whole, and the smaller set of bars is that fraction of the net savings that can be attributed to the utility C&S program. The allocation of savings to the utilities was based on a combination of the following criteria: 1) Importance of Energy Efficient Products in the Market, 2) Effort Needed for Test Methods/Research, 3) Innovativeness of Standards Idea, 4) Preparation of CASE Analysis, 5) Involvement with Stakeholders & Public Process. A detailed description of each of these factors and how they are weighted can be found in the C&S savings estimate paper (Mahone 2005).

Figure 3. 2005 Title 24 and C&S Program Electrical Energy and Demand Impacts



2008 CA Title 24 Building Energy Code: The Cycle Continues

A key point to note from this forecast of net savings: the savings rise over time and then fall as naturally occurring market trends and normally occurring code changes catch up with the 2005 building codes. The method to keep C&S program savings increasing in the future requires that the voluntary incentive and market transformation programs keep moving efficiency measures from “innovative” to “good standard practice” and ultimately into the energy codes. The voluntary programs have huge expectations placed on them for delivering even more energy savings. Promoting some of the high volume measures into codes will free up resources from the voluntary programs that were targeted towards the “late majority” or “laggards” and allows these voluntary programs to focus their energies on gaining broad market acceptance for the next big energy savings technologies and practices identified by the emerging technology programs. (Eilert et al. 2002)

Institutional support for building efficiency standards is high. Due to state budget constraints and the good working relationship between the utility C&S programs and the CEC, approximately 15 energy code proposals are being developed by utility C&S programs for the next round of standards improvement in 2008. Similar to the 2005 Standards, some proposals are expanding the scope of the Standards and others are consolidating and refining the measures advanced in earlier code cycles. Some examples are given below.

Consolidating Gains in the 2008 Standards

Skylighting. The 2005 Standards required skylights and automatic daylighting controls in large open spaces larger than 25,000 sf and with ceiling heights higher than 15 feet. This matches well the spaces that have embraced skylighting without a code requirement. Once designers are use to the general concept of the skylit space, it is easier to consider skylighting in smaller areas. The ceiling height criteria will likely remain as it is cheaper to skylight taller spaces because the skylights can be spaced further apart while maintaining illumination uniformity. In addition, the presence of a dropped ceiling, and the need for a light well, dramatically increases the cost of skylighting.

The lighting control of choice for skylighting is the photocontrol – it allows one to set a given setpoint and the lights will turn on and off to maintain a given minimum design illuminance regardless of the weather conditions. Because not that many designers or electricians were familiar with photocontrols, the 2005 Standards allowed another lighting control alternative that was more familiar, the astronomical time switch. This control turns lights on and off at fixed time offsets from sunrise and sunset. During cloudy weather the user can temporarily override the control with a timed override switch. It is thought that the astronomical time switch will not save as much energy as it may be permanently overridden to avoid the necessity of using the temporary override or set to offsets that do not save as much energy as can be expected from a photocontrol. Building department surveys will be conducted to evaluate how frequently the astronomical time switch is used is skylit designs. If astronomical time switches are infrequently used, this would support dropping the them as an alternative to photocontrols.

Outdoor lighting. The outdoor lighting power allowances in the 2005 Standards are relatively high as compared to common practice. As an example, the lighting power allowance is higher than any of the outdoor retail sites surveyed as part of the PIER outdoor lighting research. (RLW Analytics 2003) In addition, the base technology for the large wattage lamps was probe start metal halide technology. Pulse start metal halide technology has a 25% greater mean luminous efficacy than probe start metal halide systems, and is being used increasingly across the state with support from the utility incentive programs. In addition, pulse start lighting technology is likely the basis of efficacy requirements for metal halide luminaires in the 2008 Title 20 appliance efficiency standards. Thus it is likely that a review of the IESNA lighting standards for appropriate light levels, along with development of lighting models using pulse start technology, will yield lower allowed lighting power densities in many outdoor lighting applications.

Sign lighting. As mentioned earlier, the 2005 Standards contain sign lighting power density requirements for externally lit signs and filtered internally lit signs, but not for unfiltered signs such as LED "message centers" and neon signs. This sign power regulation should be completed by developing an appropriate power density for unfiltered signs. Unfiltered signs are also often on during the daytime as well as at night. The brightness that is needed during the day is much higher so that the sign can be read. Many unfiltered signs are dimmed at night to be less glaring and to save energy. This opportunity for energy savings will be investigated and appropriate recommendations made for incorporating it into the Standards.

The 2005 Standards allow an alternate compliance route for sign efficiency by requiring high efficacy light sources. Certain light sources were exempted from efficacy requirements. A proposal for the 2008 Standards will recommend that most of these sources have some characteristic that increases their efficacy, whether it be a more efficient lamp or phosphor coating, or that the device powering the lamp (ballast or transformer) is high efficiency. Since a developed market for the more efficient lamp or ballast technologies is a precursor to requiring these technologies in codes, utility program designers are talking with the lamp and ballast companies about incentives focused at higher performing products. This would pave the way for addressing the remaining technologies in the next code revision.

Expansion of Scope in 2008

Not all of the code change proposals for the 2008 Standards are based on refinements to the existing Standards. Several proposals are expanding the scope of the Standards. Similar to the approach taken in the revisions to the 2005 Standards, when the scope is expanded to include new measures, the level of stringency or the breadth of the new measures is conservatively low. Usually the calculated benefit cost ratios will be quite high for these new measures so that we can be assured that the measure is cost-effective even with the addition of unforeseen costs or realized savings lower than calculated amounts.

Sidelighting. Prior to the 2005 Standards, there were no requirements for automatic daylighting controls. In 2005, daylighting controls were required in the daylit area under skylights, but not required for the daylit areas by windows. Skylighting was chosen first because the design issues for control systems are much easier. Buildings with diffusing skylights have a fairly constant distribution of light and relatively simple lighting control strategies. In contrast, daylighting with windows, referred to as sidelighting, is more difficult due to the changing distributions of light from the sky and the moving sun. The lighting control strategies are more complex and success is less assured than with toplighting. Nonetheless many spaces are sidelit with windows and this opportunity for extending the Standards to require sidelighting savings will be pursued.

The 2008 Standards will include prescriptive requirements for daylighting controls of electric lights near large expanses of window area. These requirements will be based upon the field research of 123 sidelit spaces as described in a companion paper. (Howlett et al 2006) We have found in this study that the closer that luminaires are to the windows, the more likely they are to realize their calculated savings (i.e. they are less likely they are to be disabled). The cost savings from daylighting controls is a product of the amount of savings realized per installed luminaire, and the number of luminaires installed. Most of the costs of the daylighting controls are fixed – they do not increase significantly with the number of luminaires controlled. Given all of the above, the proposal will target those spaces with large expanses of glass, and will require daylighting controls only for those luminaires that are near the windows.

Refrigerated warehouses. The building energy standards have not regulated refrigerated warehouses, even though refrigeration loads are approximately 14% of commercial building electricity consumption (PG&E 1999). PG&E has been running a refrigerated warehouse Savings By Design program for 13 years and has developed a baseline case of common refrigerated warehouse design practice as well as commonly applied efficiency measures. In addition, the Northwest Energy Efficiency Alliance (NEEA) has developed an efficiency program and a series of case studies around the use of variable frequency drives (VFD) on refrigerated warehouse evaporator fans (Violette et al. 2003). Our analysis has found that the cost-effectiveness and energy savings of this measure alone is very significant, with benefit-cost ratios exceeding 10 to 1 and energy savings of 3 kWh/yr per sf of refrigerated space.

Demand response. As described at the beginning of this paper, electrical demand is rising faster than electrical consumption, driven by air conditioning usage and increasing growth in the hot Central Valley of California. Approval has been given to develop new utility rates, such as critical peak pricing (CPP), that are substantially 10+ times higher at time of system peak than average rates. (CPUC 2005) The utilities will be developing a communications network to transmit a demand response signal into most homes and businesses that will alert the owner or the electronic devices in the building that they are in either a time of very high electric prices or a time of low system capacity. In the first case they will be given the opportunity to save money by voluntarily curtailing load during these highest cost hours. In the second case, loads may be automatically shut-off to forestall the need for a black-out in the area. An advanced metering infrastructure (AMI) is being developed by all of the Investor Owned Utilities (IOUs) to remotely meter all of their customers and to collect electrical consumption information with enough resolution to bill according to CPP or a similar type of rate that is linked to the cost of delivering power.

Energy code proposals are being considered that would make use of communications with devices in the home or in commercial buildings to do the following:

- Set-up thermostats 4ºF during a demand response period (hot weather)
- Control some fraction of indoor lighting either by shutting off some circuits or via dimming
- Dim or turn off outdoor signs that are on during the day
- Segregate building loads between non-curtailable, rarely curtailable and readily curtailable. Then provide a means to control the rarely curtailable and the readily curtailable loads separately.

To support the development of demand response measures, a new set of time dependent valuation (TDV) factors has been developed. These factors include the residual cost of a peaking turbine allocated to the top 50 hours of the peak loads. The result is the valuation of electricity that is even more peaky than the TDV factors incorporated into the 2005 Standards. In addition, for involuntary participants of curtailments, a separate calculation has been developed to value the net benefit of an involuntary curtailment of some loads relative to an involuntary blackout of all loads.

Conclusions

The State of California has adopted policy positions that make energy efficiency the first choice amongst many for meeting its future energy needs. Appliance and Building Standards are also recognized as the most cost-effective method of realizing efficiency gains. To get the most savings out of all of our efficiency programs, we must take a broad view of how we diffuse energy innovations, from the kernel of an new idea to an established efficiency practice that is codified into law. The outline of this process, discussed by example above, is presented below:

- Develop a long range plan for each measure
  - Consider the path of R&D to Emerging Technology program and demonstration projects to Mass-Marketed Incentive program to adopted in Codes and Standards
- Collect the needed information along the way about each measure including:
  - Total market share and estimates of "naturally occurring" market share net of utility intervention
  - Market barriers
  - Appropriate and inappropriate applications
  - First costs, maintenance costs and reliability
  - Calculated and realized energy savings
  - Environmental, productivity and other non-energy benefits/losses
- Integrate measurement and verification activities for codes and standards programs with design of future energy compliance programs.

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