Mandates for Maximizing Cost-Effective Measures in Building Energy Codes: The Promise and Pitfalls during Times of Rapid Evolution

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ABSTRACT

From its inception, the California Title 24 energy code for buildings was charged with the task of reducing "the wasteful, uneconomic, inefficient, or unnecessary consumption of energy" with the key requirement that these standards be, "cost effective, when taken in their entirety, and when amortized over the economic life of the structure." Recently with the passage of California Assembly Bill 32, which requires reductions in greenhouse gases, the impetus for redoubled efforts in energy efficiency has become more acute. As this paper will show, increasing energy efficiency is one of the few greenhouse gas mitigation measures that both reduces greenhouse gases and lowers life cycle cost.

We describe the efforts by the California Statewide Codes and Standards program, implemented by the California Investor Owned Utilities (IOU) consisting of PG&E, SCE, SDG&E and SoCalGas, to increase the stringency of the 2008 California Title 24 building energy efficiency standards. In addition to reduced energy consumption, air emissions, and utility resource procurement these standards increase costs for: the building industry, building departments, energy code training programs and state government. This paper will also describe potential areas for additional savings in 2011 building standards, the resulting expected impacts on the State and a plan for mitigating these impacts.

Background

In 2003, California's lead energy agencies established an energy procurement "loading order" policy that required that the state's electrical energy and demand requirements be 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 loading order policy was enacted into law in 2005 with the passage of SB 1037[1],

After developing the market for energy efficient technologies with the early adopters through incentive programs, over time these emerging technologies become mainstream. For a significant part of the market (late majority and laggards), the technology has not been adopted due to a number of market barriers. Expenditures on voluntary programs for these mature technologies are then plagued with low net to gross rates because the program primarily attracts those consumers who would have selected the efficient technology anyway. Codes and standards are well suited to cutting through the Gordian knot of split incentives (the person making decisions on adding the efficiency features is not the person paying the energy bill) and

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

other market barriers to well-established, cost-effective energy efficiency measures. Once in the energy code, the measures are required to be installed and so become standard practice.

Sustained Investments in Energy Codes & Standards

Prior to the 2005 Title 24 energy code, efforts by California IOUs to increase the stringency of the state building efficiency standards (Title 24) and the state appliance efficiency regulations (Title 20) were considered an "informational program" with no earnings claim and no energy savings credit; i.e. codes and standards programs were considered overhead or an extra cost that reduced the cost-effectiveness of the other IOU energy efficiency programs. However, it became readily apparent that codes and standards were a powerful tool to add into the overall mix of utility efficiency programs. The California Public Utilities Commission stated in their 2006-2008 portfolio decision, "using ratepayer dollars to work towards adoption of higher appliance and building standards may be one of the most cost-effective ways to tap the savings potential for energy efficiency and procure least cost energy resources on behalf of all ratepayers."[2]

Attributing Savings to Utility Codes and Standards Programs

A mechanism for quantifying the energy impact of codes and standards efforts and rewarding the IOU's based upon these savings was needed to establish the Statewide Codes & Standards program as a resource acquisition program and unlock the capabilities of the California IOUs. The IOUs (Mahone et al 2005) developed a methodology similar to that used for attribution of savings to other energy efficiency programs. This methodology characterizes 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. The estimate of program savings starts off with the technical savings potential of the measure (typically relative to the earlier version of the energy code), and then derates the statewide savings attributable to the statewide codes and standards program by the following factors:

- Actual construction true-ups based on permits or other industry records
- Initial market penetration and naturally occurring market adoption
- Normally occurring code updates
- Non-compliance

All of these factors are difficult to predict in advance of the adoption of the code; e.g., it is difficult to predict the housing markets or market acceptance of efficient products. An ex ante (before) prediction is made for each of these factors with the understanding that the estimate will be trued up by an ex post (after) evaluation.

Since utility earnings will be dependent on measurement and verification of actual energy savings from energy codes attributable to IOU activities that lead to their adoption, California Public Utilities Commission (CPUC) sponsored verification studies will be collecting more market and compliance information than has been available in the past. This added information can also be used to help support the development of the next iteration of building standards.

[2] p. 177 Finding of Fact No. 40 (CPUC 2005)

With evaluation efforts providing feedback on how well the codes are being enforced, this information could alter the way the energy codes are developed in the future. Revisiting the process flow and logic model behind the energy codes and their enforcement may yield substantial energy savings without increasing the stringency of the code or adding costs to the law abiding building developer.

Measurement and Verification Pilot

The Statewide Codes and Standards Market Adoption and Noncompliance Rates report for SCE, prepared by Quantec & Benningfield Group in 2007 on naturally occurring market adoption and building code compliance provides insight into what type of information future codes and standards measurement and verification studies may reveal. This study surveyed market segment experts on their estimates of initial market penetration of efficient technologies and predictions of future penetration rates. The predictions were fitted into an "S" shaped "Bass" curve which predicts fastest growth rates near the middle of a product cycle. The study found substantial difficulties in measuring current market adoption, and more so in forecasting future adoption rates.

Table 1. Estimated Non-compliance Rates for Selected 2005 Title 24 Measures[3]

Building Measure	Estimated Non-compliance Rate	Precision of Estimate
Residential		
Hardwired lighting	28%	3%
Window replacement	68%	7%
Duct improvement	73%	1%
Nonresidential		
Lighting controls under skylights	44%	10%
Cool roofs	50%	3%
Bi-level lighting controls	n/a	n/a
Ducts in existing buildings	100%	2%
Duct testing/sealing in new buildings	100%	1%

This study also measured non-compliance rates of various code measures. For the selected measures shown in Table 1, the compliance results had a wide range from relatively high (72%) for high efficacy lighting in new homes to very low (0%) for duct sealing in nonresidential buildings. This study indicates that a significant energy savings resource is available through improved code compliance.

Change Theory Logic Models

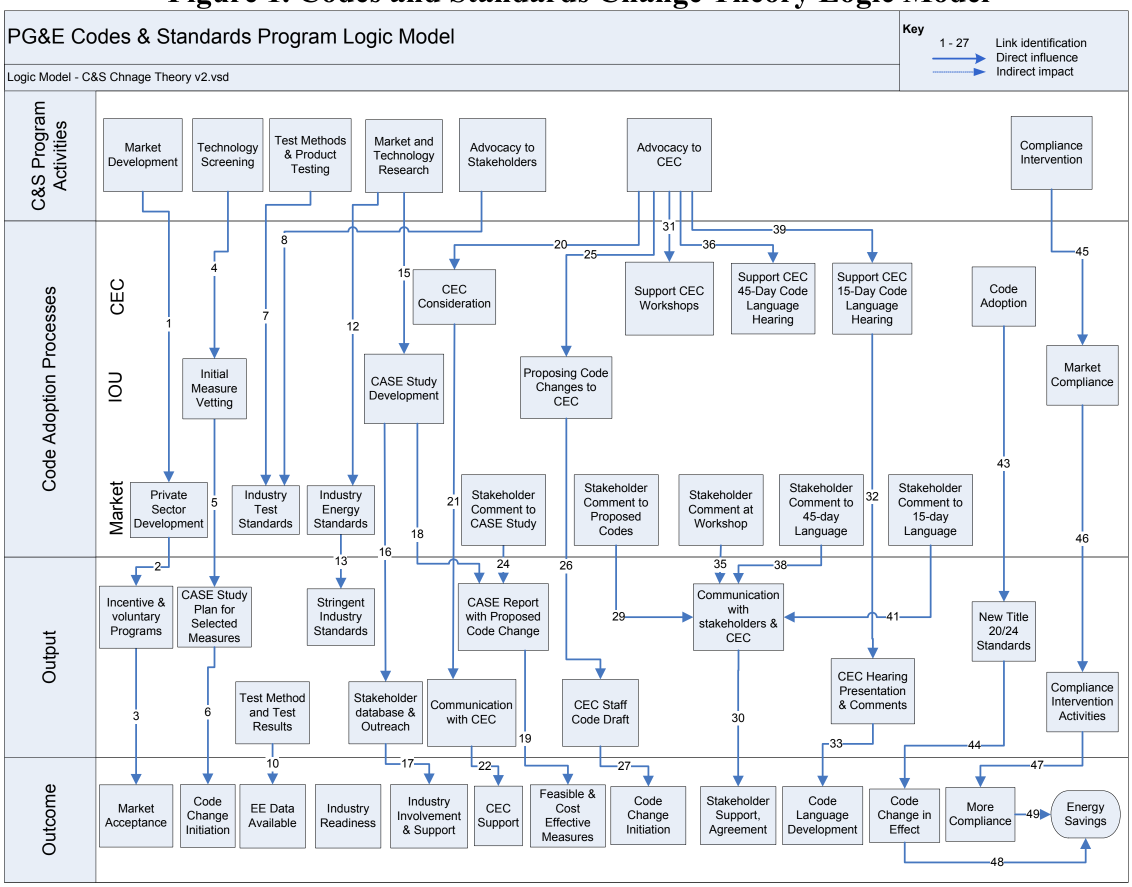
Evaluating a Codes and Standards (C&S) program is rendered more tractable if there is an overall program change theory. This change theory identifies the steps planned to proceed from one level of energy consumption under the existing energy code to reduced energy consumption under a more stringent energy code regime. The change theory hypothesizes that if the IOU's conduct certain activities in conjunction with the codes and standards stakeholders, then a certain outcome should follow. Since the overall plan can become quite complex, the plot becomes easier to follow if one has a graphical roadmap of the logic of the change theory (a logic model).

An illustrative C&S change theory logic model diagram is shown in Figure 1. From left to right this model follows the chronological flow of the Title 24 adoption process. For each one the Program Activities one can follow from top to bottom, showing how the particular activities are assumed to affect a desired Outcome. The program does this by impacting various

[3] p. 10 Table 4. "Summary of Building Measure Noncompliance Estimates." (Quantec & Benningfield 2007)

stakeholders to the Code Adoption Process which ultimately has a particular Result and a particular Outcome. In each one of the links between Activities, Processes, Results and Outcomes there is a measurable indicator (referenced by the numbered arrow). By evaluating these measurable links, the evaluator can identify how closely the activities and outcomes matched the change theory and how a series of interrelated activities contributed to the code measure being successfully adopted. This is very helpful when the item one ultimately wants to measure is not directly measurable (e.g., how much of the energy savings from the new energy code are attributable to the activities by the IOUs).

Figure 1. Codes and Standards Change Theory Logic Model



Source: PG&E Codes and Standards Program

Increased Energy Savings from the "2008" Title 24 Energy Code[4]

The "2008" edition of the Title 24 building energy efficiency code will likely take effect around mid-2009. The original schedule called for this code having the same effective date as the other California building codes. This schedule slipped based upon the volume of valid code change proposals and the controversy that surrounded some of them. The majority of major code change proposals were developed by the California IOU's. The measures adopted in the 2008 version of the California Title 24 energy code can be characterized in terms of their

[4] Detailed reports describing the technical and feasibility analysis for most of the following measures can be found at the following website: http://www.energy.ca.gov/title24/2008standards/prerulemaking/documents/index.html

developmental stages from scope expansion to consolidation or refinement of a measure that was introduced in an earlier version of the energy code (McHugh 2006).

A notable scope increase in the 2008 standards is the regulation of refrigerated warehouses for the first time. In the past, refrigerated warehouses were treated as "process load," that was outside of the scope of the standards. For the 2008 Title 24 standards, refrigerated warehouses were treated as another building activity (storage at low temperatures), while blast freezers, ice cream makers etc. were exempted due to their nature of being a process that converts matter from one condition to another.

California IOU CASE Reports

When proposing a code change, the C&S program produces a Codes and Standards Enhancement (CASE) report. These reports provide the technical and feasibility background information to the CEC and other stakeholders so an informed decision can be made on the advisability of adding the measure to the building standards. The following list contains the CASE measures proposed by the C&S program and adopted into the revised 2008 Title 24 standards:

Nonresidential CASE Reports:

- Insulation – insulation requirements updated to minimize the life cycle cost of buildings.
- Overall envelope – envelope trade-offs used to be based on cooling loads and heating loads. New trade-offs are based on time dependent valuation (TDV) of energy costs, thus trade-offs can be made between fuel types. Savings would be neutral (zero) except that this method more accurately models window heat gain. Multi-layer windows are given more credit since angular SHGC (solar heat gain coefficient) drops off with incident angle more quickly with multi-glazed fenestration than with single glazed.
- High slope cool roofs – more reflective roofs required in the hottest climate zones.
- Skylighting – skylights and automatic daylighting controls (photocontrols) required in large area low rise spaces with high ceilings (> 15 ft) directly under a roof. Threshold space floor area criteria reduced from 25,000 sf to 8,000 sf. Rule set re-written to make enforcement easier.
- Sidelighting – new definition for the "primary sidelit area" (the area within one window head height from perimeter windows) and a mandatory requirement for automatic daylighting controls (photocontrols) when the primary sidelit area in a room is greater than 2,500 sf.
- Indoor lighting – modest (20%) reductions to retail display lighting power allowances for stores complying using the less stringent "tailored lighting method." Only the 10% of stores with the highest lighting power densities use this method. More stringent requirements were thwarted by costs of high efficacy display lighting.
- Demand responsive (DR) lighting controls – in retail stores greater than 50,000 sf, automated controls that can shed 15% of lighting load in response to a utility cost or curtailment signal.
- Outdoor lighting – based on IESNA (Illuminating Engineering Society of North America) consensus standards and cost-effective high efficacy lighting sources (primarily pulse start metal halide).

- Signs – technology efficiency improvements limited by broad temperature range; most savings due to a mandatory control requirement for time and daylight controls.
- Variable air volume air conditioning systems
  - Demand control ventilation – required for higher occupant density locations (auditoriums, retail, assembly etc.). Classrooms are not affected.
  - Supply air temperature reset – based on load or outdoor air temperature
  - 20% minimum flow rate and reverse acting thermostat – reduces "short cycling" of air from supply register back into return. Also increases thermal comfort.
  - Automated global temperature adjustment capability – for air conditioning systems with direct digital control (DDC) to the zone level, all new systems will have the capability to automatically reset all non-critical space temperature settings upon receipt of a utility cost signal or request to curtail signal.
- Refrigerated warehouse envelope and mechanical measures – this included sizing of condensers and requirements for variable speed fans.
- Central DHW recirculation loops – requirements for check valves and air release valve to prevent water flowing backwards during periods of high hot water use and to prevent recirculation pump cavitation.

Residential CASE Reports

- Window U-factor – decreased allowable U-factor based on vinyl windows for primary residential "package" of measures.
- Pools – requirement for low pressure drop plumbing fittings, multi-speed pumping and timeclock control of pumping.

As can be seen in Table 2, the IOU sponsored measures first year's (in 2009) technical savings potential total approximately 244 Gigawatt-hours per year of electricity and 9.97 Million therms of natural gas. The savings from these measures increase for each year of new building stock built after the code's effective date. Thus after the 10th year, the annual savings should be approximately ten times higher.

In comparison, the IOU sponsored CASE studies for the 2005 Title 24 standards had a first year technical savings potential of approximately 163 GWh/yr and 3.9 Million therms/yr. Thus the rate building energy code stringency is accelerating.

Table 2. Summary of 1st Year Energy Savings

IOU CASE Study Measure Description	1st Year Savings (GWh)	1st Year Demand Savings (MW)	1st Year Gas Savings (Mtherms/yr)
Nonresidential			
Envelope Insulation	27.42		1.19
Overall Envelope	0.10		
Cool Roof High Slope	65.00	6.00	-0.49
Site Built Fenestration	N/A		
Skylighting	4.48	0.68	
Sidelighting	1.57	0.64	
Indoor Lighting	21.10	4.70	
DR Indoor Lighting	0.06	3.20	
Outdoor Lighting	7.82		
Outdoor Signs	1.38		
VAV HVAC	23.20	34.90	3.00
Refrigerated Warehouses	15.60	1.80	
Residential			
Residential Fenestration	19.55	13.00	6.22
MF DHW Distribution			0.05
Swimming Pool	56.50	31.60	
Totals	**243.78**	**96.52**	**9.97**

CEC Sponsored Measures

In addition to the IOU sponsored CASE studies, California Energy Commission (CEC) staff and their consultants have investigated a number of measures for further savings. Some of these measures were identified in the CEC administered Public Interest Energy Research (PIER) program as having energy savings and code feasibility. Others are "clean-up" measures meant to clarify or simplify enforcement of the energy code in response to questions from designers or enforcement authorities.

CEC Sponsored Nonresidential Measures

- Variable volume single zone air conditioners – effective in 2011, large single zone rooftop units are required to have variable speed fans and variable refrigerant flow compressors. This concept was introduced at the hearings for the 2005 standards by Southern California Edison, but this was introduced for the 2008 Title 24 standards by the CEC's consultant.

CEC Sponsored Residential Measures

- Refrigerant charge test – a substantial number of units are either over or under- charged. Requirement for validation of refrigerant charge or an on-board diagnostic sensor to indicate refrigerant charge.
- Airflow test – validation of test to assure HVAC units are not "starved" for air which reduces their efficiency.
- Fan power draw – maximum hp limits placed on air conditioners
- Residential indoor lighting refinements
- Cool roofs – moderate levels of reflectance required for high slope roofs.

Measures Outstanding or Postponed

EER/SEER: Loophole Not Yet Closed

The current compliance trade-off approach assumes SEER (Seasonal Energy Efficiency Ratio) 13 air conditioners and heat pumps to have an EER (Energy Efficiency Ratio @ 95 degree F) rating of 10. A PG&E sponsored market survey found that almost all SEER 13 air conditioners sold in California have an EER rating of 11 or higher. As a result, the minimum efficiency air conditioner (EER 11) receives a whole building compliance credit as high as 7% in the hottest climate zone. This credit essentially reduces the stringency of the standard as this credit can be offset by installing less efficient building components elsewhere in the building. The barrier to overturning this loophole may be the federal National Appliance Efficiency and Conservation Act (NAECA).

Measure Dropped: Programmable Communicating Thermostats (PCTs)

Language in the building energy standard was written to require the installation of programmable communicating thermostats. These thermostats would be designed to automatically increase the air conditioning setpoint without override during a power emergency where the alternative is a blackout. These PCTs could also support voluntary programs which provide incentives for increasing air conditioning thermostat setpoints during times of peak electrical demand. The lack of an override during a power emergency gave rise to a broad backlash by citizens concerned about "Big Brother" controlling their thermostat. This technology will be considered under a later load management proceeding held by the California Energy Commission and will focus only on its enabling capability to respond to price signals.

California's Response to Global Warming

Global temperature rise is considered to have a number of negative impacts on human well-being: sea level rise and flooding of coastal areas, more extreme weather events (hurricanes, tornadoes etc.), increased cardio-respiratory diseases due to higher concentrations of ground-level ozone, reduced snow pack in the Western US with more flooding in winter and less water availability in summer, more pests and more fires in forests and increased numbers of heat waves in cities. Though some parts of the world may experience local benefits, the benefits for these areas are reduced under high temperature rise scenarios.

The California State Government appears united in being "first out of the gate" in its efforts to combat global warming. The state has a number of motivations for taking a leadership role on this issue.

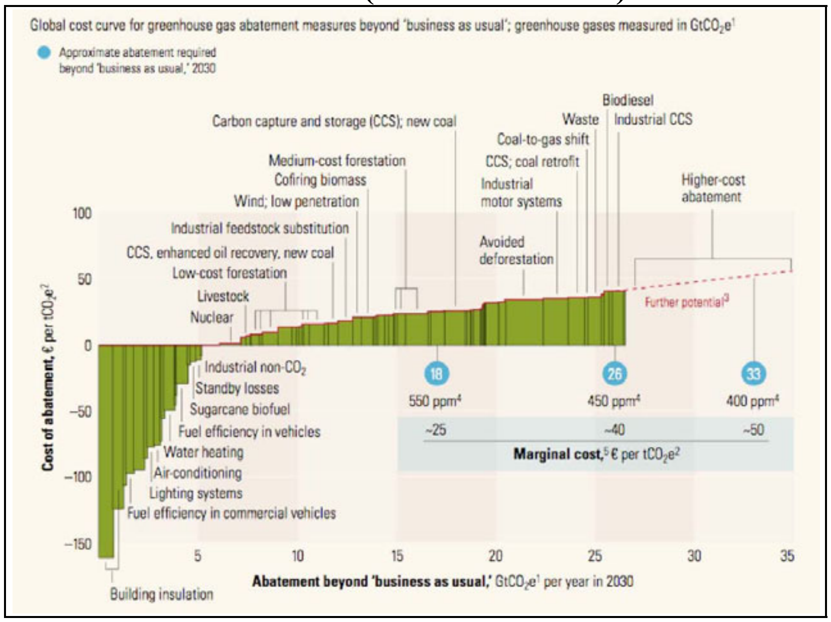
1. Global warming is predicted to increase sea levels; California has a substantial amount of high value property near sea level at risk
2. Agriculture is a key component of California's economy and is facing serious constraints due to water availability.
3. California has a number of constraints related to power plant construction with air quality being a key issue for power plant siting. California has a relatively long experience of displacing new power plant construction with energy efficiency.
4. California has an air quality problem. Half of its counties exceed the Federal 8 hour ozone standard. Of the 25 counties in the US with the highest levels of ozone pollution, 12 of these counties are in California.[5]
5. California has a history of capitalizing on new technologies. Developing global warming strategies in California first could yield significant financial benefits to California businesses as these strategies are replicated in other parts of the world.

Supply Cost Curve of Greenhouse Gas Abatement

In the past, energy supply curves have been used to display the economics of energy efficiency in the same format of that for supply side power generation technologies. The cost of delivered energy services is plotted on the vertical axis versus how much energy (or saved energy) can be delivered at that price on the horizontal axis.

[5] http://www.californialung.org/press/080501SOTA.html

Figure 4. Supply Cost Curve for Greenhouse Gas Abatement (Enkvist et al 2007)



Enkvist et al (2007) have developed a similar cost curve for reducing carbon emissions whether it is from energy efficiency, carbon capture and sequestration or other carbon mitigation technologies. In this case, the cost of carbon abatement is plotted on the vertical axis versus the tons of carbon reduction available from each technology at that cost level. In this model, a marginal cost estimate of 40 Euros/ ton ($62/ton) of CO_2 equivalent would be sufficient to stabilize greenhouse gases to 450 ppm of carbon dioxide equivalent. This estimate would place the cost of carbon stabilization in 2030 between $780 Billion and $1.7 Trillion/yr or approximately 0.6% to 1.4% of the world GDP. Though this is a large sum of money for environmental security, it is less than the expenditures for insurance[6] or on military budgets.[7]

As a point of reference, the current environmental externality value associated with carbon dioxide is $8 per standard ton in 2004 dollars[8] in the time dependent valuation (TDV) used to calculate cost-effectiveness of the California energy codes and in the "E3 calculator" which is used to calculate the cost-effectiveness (total resource cost test) of California IOU programs. Thus the externality cost currently used the cost-effectiveness of energy code measures or energy efficiency programs fall way short of the levels needed to hit a moderate carbon reduction target.

It is worth noting that the carbon reductions due to energy efficiency measures have a negative carbon abatement cost; they reduce emissions of carbon dioxide while yielding a positive net financial return on investment. Most of the supply side carbon reduction measures, (nuclear, carbon sequestration, PV's etc) have a negative financial impact. Thus the efforts to maximize savings from energy efficiency are a "no regrets" response to global warming. In addition, reducing energy consumption also reduces emissions for NO_2, CO and particulates which have more immediate negative health consequences.

If a $62/ton carbon tax or carbon certificate were implemented, a substantial amount of additional energy efficiency options would show up on the cost curve that are not currently cost-

[6] p. 45 Enkvist et al (2007) "…global insurance industry's turnover (excluding life insurance) - some 3.3 percent of global GDP in 2005."

[7] 120 out of the 172 countries in the web page "Rank Order - Military expenditures - percent of GDP" in the *CIA World Factbook* spend 1.4% or more of their GDP on military expenditures. The United States is listed as spending 4.05%. https://www.cia.gov/library/publications/the-world-factbook/rankorder/2034rank.html

[8] Escalating at 5% per year, from personal correspondence with Snuller Price, E3.

effective. Just how much additional cost should be allocated to the value of reducing carbon will impact which measures can be applied to the next generation of energy codes.

AB 32 – Greenhouse Gas Mitigation Framework

California Assembly Bill 32 (Nunez) directs the California Air Resources Board to adopt a statewide greenhouse gas emission limits that would reduce greenhouse gas emission levels to 1990 levels by 2020. This will require substantial per capita energy reductions as the population of California is projected to be 42 million people in 2020, a population increase of 40% as compared to the almost 30 million people in California reported in the 1990 census. This population increase is comparable to the predicted global population increase from 5.3 Billion in 1990 to 7.5 Billion in 2020.[9] Energy codes will have to be a significant part of this plan.

This bill also calls for the air resources board to monitor greenhouse gas emissions and to set a schedule of fees for emitting greenhouse gases.

California Executive Order S-3-05

In June of 2005 Governor Schwarzenegger signed this executive order which set the following greenhouse gas (GHG) limits for the state of California: *"by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce GHG emissions to 1990 levels; by 2050, reduce GHG emissions to 80 percent below 1990 levels..."* This continuous and aggressive timeline helps send consistent goals to all levels of State Government. To make inroads on this the first goal, stabilizing carbon emissions in 2010 so they are no more than 2000 will require new thinking on energy efficiency and carbon emissions. Any new growth will require a reduction in existing carbon use and require non-carbon fuel sources. The 2050 goal is consistent with the IPCC strategy required to keep $C0_2$ concentration levels below 400 ppm ($C0_2$ equivalent level below 500 ppm) and to keep long term global temperatures within 2ºC of pre-industrial temperatures. (IPCC 2007b)

AB 1109 (Huffman Bill) – Lighting Efficiency Targets

California Assembly Bill 1109 (Huffman) requires the CEC to develop lighting energy efficiency standards by December 31, 2008, that "…would be structured to reduce average statewide electrical energy consumption by not less than 50% from the 2007 levels for indoor residential lighting and not less than 25% from the 2007 levels for indoor commercial and outdoor lighting by 2018." An analysis conducted by the California Lighting Technology Center (CLTC) found that the goals for residential energy consumption would require wholesale replacement of incandescent lamps with high efficacy lamps such as compact fluorescent or efficient versions of light emitting diodes. Replacing incandescent with higher efficacy incandescent or halogen lamps would not be able to provide the required energy reductions. Thus, this is another aggressive goal that requires a coordinated effort by all stakeholders.

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[9] Johan van der Heyden. GeoHive: Global Statistics "Historic, current and future population." http://www.xist.org/earth/his_proj.aspx

Growth Areas in Codes and Standards

From the policy arm of California government, clear direction has been given on the objectives for codes and standards and energy efficiency programs. The following are some general areas with likely substantial savings:

Compliance Improvement

As discussed earlier, a pilot evaluation of some energy code measures found that a subset of these measures had 0% compliance with the building energy code. A clear understanding of the reasons for the lack of compliance and enforcement will help in developing more effective future energy codes and compliance improvement strategies.

Existing Buildings

Each year approximately 100,000 single family homes and 50,000 multi-family dwelling units are constructed. These buildings are within the scope of the Title 24 energy code. There are about 8 million pre-existing single family homes and 4 million multi-family dwelling units.[10] Since homes are on average sold every seven years[11], 1.4 million existing homes and (assuming same turn-over for rental properties) 570,000 existing multi-family units are involved in a financial transaction. Requirements to the real estate code that require the most basic efficiency measures (attic insulation, weather sealing etc.) installed at time of sale would have a huge impact – potentially impacting 10 times as many residential buildings as do the current residential standards.

Performance Trade-off Calculations

The performance trade-off method as described in the Title 24 Alternative Compliance Method (ACM) Manual makes use of a building simulation to trade-off between different building components. The limitations of this computer model (DOE-2.1E) hinder the use of advanced energy efficiency technologies to comply with the energy code. The following is a list of areas in the current ACM that can be improved:

1. Comfort Model – homes in the mild coastal regions of California do not need air conditioners. It would be desirable to give credit to homes that do not have air conditioners as long as it can be reasonably expected that occupants in these homes will be comfortable enough that these homes will not be retrofitted with air conditioners later on.
2. Multi-speed compressors – in many cases, higher SEER air conditioners have two-stage compressors. Better modeling of compressor performance will be useful for understanding the true impacts of equipment selection.

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[10] http://www.dof.ca.gov/HTML/DEMOGRAP/ReportsPapers/Estimates/E8/E-8.php

[11] Median duration at residence is 7 years for homeowners and 1 year for renters. Jason P. Schachter and Jeffrey J. Kuenzi. US Census. Seasonality of Moves and The Duration and Tenure of Residence: 1996, data extracted from Figure 4. Duration of Current Residence by Current Tenure: 1996. http://www.census.gov/population/www/documentation/twps0069/twps0069.html

3. Displacement ventilation – ventilation systems that move air though a room as a continuous bulk of air (air is stratified) have higher ventilation effectiveness and consequently require less flow to achieve the same level of indoor air quality.
4. Natural ventilation – fan energy is a significant fraction of non-residential energy consumption. Being able to predict the natural flows of air through a building will allow designers to design with less forced ventilation.
5. Refrigeration model – the current refrigeration requirements in Title 24 are mandatory. With a refrigeration model in the performance method, some of the requirements could be prescriptive and traded-off against others; this would allow more flexibility for least cost methods of achieving a given level of energy efficiency.
6. Daylighting – the split flux model in DOE-2 (all versions) overestimates the amount of reflected daylight available far from the window. (Koti & Addison 2007). This model could be acceptably used for the primary sidelit daylight area but overestimates the amount of daylight available in the secondary sidelit daylight area.

Developing a performance model with all of these features is a substantial undertaking. The savings that would result from such a model is significant but so also is the cost of development and then developing useful user interfaces and enforceable requirements associated with these tools.

Impact on State and Local Governments

The Governor and the Legislature have set some very aggressive energy goals for California. If these goals are achieved, California will surely be a global leader in reversing the damage done to the atmosphere that maintains the lives of all people. The partial list below describes some of the expanded activities that will be required of impacted state and local agencies:

California Energy Commission

- Increase public process for broader scope energy regulations
- Develop and maintain a database of outdoor lighting zones, local lighting zone changes and local outdoor lighting ordinances
- Develop and maintain a list of certified lighting controls (Section 119 Title 24)
- Develop and maintain enhanced performance method software
- Develop and maintain a database of performance method data

California Department of Real Estate

- Oversee changes to real estate laws and administrative procedures to implement a requirement for energy upgrades at time of sale (residential) or at time of change of lease (commercial).
- Oversee adding energy benchmarks to MLS (multiple listing service) listings
- Update training of real estate agents

Building Departments

Increase and expand scope of enforcement:

- Outdoor lighting
- Unconditioned buildings
- Increase stringency in reviewing acceptance tests
- Improve process for reviewing and tracking installation certificates
- Improve process for reviewing and tracking HERS rating certificates

Recommendations

Increased funding for state and local government services are required to develop and support increasingly stringent energy codes. This effort should be funded as part of the overall Greenhouse Action Plan if we are expecting to meet the aggressive greenhouse reduction goals. The funding for these expanded activities is a small fraction of the revenues that would be collected from the levying of charges for carbon certificates. We expect that most of the revenues raised from the sales of carbon certificates would be expended on transfer payments to support energy efficiency or low carbon sources of power. Carbon certificates need not be limited only to sources of power but could also be charged as "feebates" for higher energy consumption equipment.

Given the aggressive goals envisioned for present and future codes and standards, the following steps should be taken to squeeze more low cost energy savings out of energy codes.

- Reconsider a new energy cost baseline for efficiency programs and energy codes based on 2020 and 2050 goals. Should this include a higher "environmental adder" for evaluating the cost-effectiveness of energy code measures and voluntary programs?
- Expand the role of codes and standards programs
  - More cost effective than other energy efficiency programs (up to a certain point)
  - Lower cost than new generation
  - Consider adding measures to codes and standards that in the past were not cost-effective but are cost-effective when a larger "environmental adder" is included.
- The CPUC should structure measurement and verification of codes and standards programs so the information can be used twice: 1) to allocate earnings claims to the IOU's for their efforts and 2) to assist future code development by characterizing building markets and processes, and identifying code implementation and enforcement barriers.
- IOU's can implement and test the feasibility and costs of the next generation of energy codes by incorporating these measures now in emerging technology and incentive programs.
- The next generation of energy codes can also be pilot tested in local jurisdictions which have aggressive climate protection objectives of their own.
- IOU's should provide more support in code development process – but there is a limit on how much oversight and control the state government can relinquish.

- The state government must invest in code development and code enforcement to reap the benefits of enhanced energy codes. This funding to state and local agencies needs to be considered as part of the overall Greenhouse Action Plan.

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