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CHANGING CALIFORNIA CODE: FINDING THE NEXT SAVINGS OPPORTUNITIES

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ABSTRACT

Every three years, the Codes and Standards Enhancement (CASE) Initiative recommends updates to the California Building Energy Efficiency Standards (Title 24, Part 6). This paper documents the feasibility, energy implications, and cost implications of four proposed code changes for the 2019 code cycle: ASHARE 62.1 alignment, ASHRAE 90.1 alignment, cooling tower minimum efficiency updates, and new lab exhaust regulations. The assessment considers an examination of the state of the market, energy savings, life-cycle costs, and statewide consequences. Finally, the paper discusses modeling challenges that arise when trying to predict savings at a large scale and its implications on code.

INTRODUCTION

The Title 24, Part 6 Building Energy code was created in 1978 by the California Building Standards Commission in response to a legislative mandate to reduce California energy consumption. Since the original energy code was published, the California Energy Commission has been tasked with updating the code to increase stringency, enforceability, cost effectiveness, and usability, as well as the harmonization with other energy standards such as ASHRAE 90.1.

Every three years, the California Utilities Statewide Codes and Standards Team, which consists of four Investor Owned Utilities (IOUs) and two Publicly Owned Utilities (POUs), leads the Codes and Standards Enhancement (CASE) Initiative, a program to recommend updates to the California Building Energy Efficiency Standards (Title 24, Part 6) to the California Energy Commission. These proposals are organized into CASE Reports, which describe the code change proposal, analyze market impacts, and provide a cost effectiveness analysis to ensure proposals will have a positive net-present value over 15 (nonresidential buildings) or 30 (residential buildings) years.

The nonresidential HVAC proposals for the 2019 edition of Title 24, Part 6 covered in this writing, later referred to as “measures”, include an ASHRAE 62.1 ventilation standards, several ASHRAE 90.1-based proposals, a new prescriptive cooling tower efficiency requirement, and a proposal modifying requirements for lab exhaust systems.

The ASHRAE 62.1 measure is unique in this group since the main motivation for the measure is improved indoor-air-quality rather than energy savings. The measure proposes modifying the existing ventilation requirements in Title 24 by adopting the ASHRAE 62.1 ventilation rates, space types, and calculation methods. Additionally, the measure considers adding a MERV 13 filtration requirement to all conditioning systems.

The ASHRAE 90.1 measures are based on updates to the 2016 ASHRAE 90.1 energy standard. The proposals suggest adopting modified versions of ASHRAE 90.1 language. The proposals differ from the original ASHRAE 90.1 since Title 24 requires a separate cost-effectiveness analysis using the local Title 24 climate zones, and incorporating California’s higher energy cost. The result of this is that the requirements are more stringent than the original 90.1 language. The proposal includes the addition of ASHRAE’s prescriptive heat recovery requirement, but modified to require higher effectiveness, and to be required in more climate zones. The 90.1 fan power allowance is also proposed for ASHRAE 90.1, but Title 24’s higher energy cost results in a modified proposal that is more stringent. The latest ASHRAE 90.1 efficiency requirement tables are proposed to be adopted into Title 24. ASHRAE 90.1’s new language regarding waterside economizer is also proposed, which encourages good practices and emphasizes integrated operation. Additional proposals add 90.1 requirements surrounding use of transfer air and demand controlled ventilation to Title 24. Finally, the last 90.1 proposal proposes a revamped occupant sensor ventilation shut-off control, which allows unoccupied rooms to shut-off ventilation rather than the 2016 Title 24 requirement to provide 25% of normal ventilation rates.

The cooling tower efficiency proposal examines the impact of adding a higher efficiency prescriptive requirement for axial cooling towers of 80 gpm/hp compared to the mandatory requirement of 42.1 gpm/hp. This proposal only effects large towers above 900 gpm, corresponding to California's requirement for 300 ton and larger cooling plants to be water-cooled.

Finally, updates to the requirements surrounding lab exhaust fans are being recommended, which propose a requirement for designers to choose between wind-responsive exhaust stack control, contaminant concentration control, and low pressure exhaust fans for the lab-exhaust system.

This paper describes the modeling methods and processes used to show cost effectiveness for the proposed Title 24 code changes, and reports the modeling results, as well as estimated statewide energy savings as a result of the adoption of the proposals.

METHODOLOGY

To assess the energy, demand, and energy cost impacts, the Statewide CASE Team compared the simulated energy consumption of buildings using current Title 24, 2016 minimally code compliant practices to buildings using design practices that will comply with the proposed code requirements. For all measures for which there were existing Title 24, Part 6 requirements, batch processing was done in California Building Energy Code Compliance for Commercial/Nonresidential Buildings Software (CBECC-Com) for all applicable building types. In instances where modeling the proposed code changes was not possible in CBECC-Com, batch processing was done in OpenStudio, using the EnergyPlus platform.

The Energy Commission provided guidance on the type of prototype buildings that must be modeled for each respective measure. For all measures for which there are no existing requirements in Title 24, Part 6, and therefore no existing rulesets in CBECC-Com, the Statewide CASE Team used current design practices as the baseline conditions and performed spreadsheet modeling to calculate energy savings from the baseline. The energy savings from these measures is climate dependent, and therefore varies by climate zone. As a result, the energy impacts and cost-effectiveness were evaluated by climate zone.

The Energy Commission establishes the procedures for calculating lifecycle cost-effectiveness. In this analysis, incremental first cost and incremental maintenance costs over the 15-year period of analysis were included. Design costs were not included nor were the incremental cost of code compliance verification. Incremental maintenance cost is the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the period of analysis. The present value (PV) of equipment and maintenance costs (savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2019 Time Dependent Valuation energy (TDV). The present value of maintenance costs that occurs in the nth year is calculated as follows:

$$\mathrm{PV(n)} = \mathrm{Maintenance\ Cost} \times \left[\frac{1}{1+\mathrm{d}}\right]^{\mathrm{n}} \quad (1)$$

The TDV energy cost savings from electricity savings were also included in the evaluation. TDV energy is a normalized format for comparing electricity and natural gas cost savings that includes the cost to provide energy based on time of use, as well as other variations in cost due to climate, geography, and fuel type. The TDV cost impacts are presented in 2020 present value dollars. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDV kBtu." Peak demand reductions are presented in peak power reductions (kW). The Energy Commission derived the 2020 TDV values that were used in the analyses for this report.

According to the Energy Commission's definitions, a measure is cost-effective if the benefit-to-cost (B/C) ratio is greater than 1.0. The B/C ratio is calculated by dividing the total present lifecycle cost benefits by the present value of the total incremental costs. After calculating the cost B/C ratio and cost savings for each climate zone, the Statewide CASE Team then calculated the first-year statewide savings by multiplying the per-unit savings, by the statewide new construction forecast for 2020. The first-year energy impacts represent the first-year annual savings from all buildings that will be completed in 2020. The lifecycle energy cost savings represents the energy cost savings over the entire 15-year analysis period. The statewide savings estimates do not take naturally occurring market adoption or compliance rates into account.

RESULTS

ASHRAE 90.1 Alignment

The proposed code change will change sections related to space conditioning system in Title 24, Part 6 to align with changes in ASHRAE 90.1-2016 which include the following:

- Fan System Power
- Exhaust Air Heat Recovery
- Equipment Efficiency
- Waterside Economizer:
- Transfer Air for Exhaust Air Makeup
- Demand Controlled Ventilation for Classrooms
- Occupant Sensor Ventilation Requirements

The primary objective of this code change is to ensure Title 24, Part 6 is the same or better in energy performance compared to ASHRAE 90.1 - a nationally adopted standard. California typically reviews revisions to ASHRAE 90.1 on a measure-by-measure basis to identify potential revisions to Title 24, Part 6. It should be noted that ASHRAE 90.1 is designed to be applicable for all states. Therefore, some of the measures in ASHRAE 90.1 are not ideally suited for California. Often, the ASHRAE 90.1 requirements that are not well suited for California will be modified so they are more appropriate for each California climate zone.

The Statewide CASE Team calculated the first-year statewide energy savings by multiplying the per prototype building savings by the statewide new construction forecast for 2020.

Table 1 ASHRAE 90.1 Statewide Savings

1st Year Electricity Savings	1st Year Peak Electrical Demand Reduction	1st Year Natural Gas Savings	Lifecycle PV Energy Cost Savings
29.8 GWh	13.7 MW	0.5 million therms	$103.8 million

Using the results from the prototype models, and given data regarding the new construction forecast for 2020, the Statewide CASE Team estimates that the proposed code change will result in annual statewide electricity savings for new construction of 29.79 GWh with an associated demand reduction of 13.66 MW. Natural gas use is expected to decrease by 0.51 million therms. The energy savings for buildings constructed in 2020 are associated with a present valued energy cost savings of approximately PV $103.77 million in (discounted) energy costs over the 15-year period of analysis.

ASHRAE 62.1 Alignment

The proposed code change will expand Title 24, Part 6 Table 120.1-A – Minimum Ventilation Rates to include and specify ventilation rates for all Title 24, Part 6 occupancy categories, referencing the rates in ASHRAE 62.1 Table 6.2.2.1 Minimum Ventilation Rates in Breathing Zone, multiplied by 130 percent.

The primary objective of this code change is to protect public health and safety by recommending requirements that will preserve or improve indoor air quality. According to the California Energy Commission, a cost-effectiveness analysis is not required if the primary objective of the code change proposal is to protect public health and safety. Hence, the statewide impacts of the nonresidential indoor air quality proposed code change do not include a cost-effectiveness analysis.

Nonetheless, the Statewide CASE Team calculated the first-year statewide energy savings by multiplying the per prototype building savings by the statewide new construction forecast for 2020.

Table 2 ASHRAE 62.1 Statewide Savings

1st Year Electricity Savings	1st Year Peak Electrical Demand Reduction	1st Year Natural Gas Savings	Lifecycle PV Energy Cost Savings
8.0 GWh	(0.87) MW	3.4 million therms	$86.1 million

Using the results from the prototype models, and given data regarding the new construction forecast for 2020, the Statewide CASE Team estimates that the proposed code change will result in annual statewide electricity savings for new construction of 8.0 GWh with an associated demand increase of 0.87 MW. Natural gas use is expected to decrease by 3.4 million therms. The energy savings for buildings constructed in 2020 are associated with a present valued energy cost savings of approximately PV $86.1 million in (discounted) energy costs over the 15-year period of analysis.

Lab Exhaust Control

The proposed code change will add new prescriptive requirements to Title 24, Part 6 Section 140.9 – Prescriptive Requirements for Covered Processes, regulating the power consumption of exhaust fans serving laboratories and factories. Laboratories and factories often deal with pollutants that can be harmful to occupants. Therefore, they require high volume exhaust systems that allow for safe release and dispersion of harmful chemicals into the ambient outdoor environment. The primary objective of this code change is to minimize laboratory and factory exhaust energy consumption, while still maintaining health and safety of building occupants. The proposed code change will provide a limited allowance for process discharge exhaust fan power. If the prescriptive fan power limit cannot be met, numerous pathways towards compliance will be provided including exhaust control by a rooftop anemometer or exhaust control by a contaminant sensor.

Table 3 Lab Exhaust Statewide Savings

1st Year Electricity Savings	1st Year Peak Electrical Demand Reduction	1st Year Natural Gas Savings	Lifecycle PV Energy Cost Savings
9.3 GWh	0.9 MW	N/A	$23.2 million

To comply with this new code requirement, designers will have to decide what path toward compliance is best suited for their projects. A conventional exhaust system, which comprise of a tall exhaust stack, allows for the safe release of discharge air at a relatively low discharge velocity. This option would likely satisfy the allowance for process discharge exhaust fan power. However, tall stacks tend to be undesirable by architects due to their high visibility. To reduce the stack height, an alternative to the conventional system is an induced, or entrained, exhaust system. An induction exhaust fan entrains outdoor air and combines it with discharge air and bypass air to achieve larger momentum. This in turn creates an equivalent effective plume height while simultaneously allowing for a shorter exhaust stack.

Although most designers feel as though the two systems provide an equivalent level of safety to building occupants, induction exhaust fans require significantly higher fan power than that of the conventional exhaust systems. If an induction exhaust fan were specified for a project, it would likely be unable to meet the fan power allowance, and the project would be obligated to use wind speed exhaust control or contaminant concentration exhaust control, which both require an additional upfront cost.

Cooling Tower Efficiency

The proposed code change will add a requirement for Cooling Tower efficiency in the prescriptive section Title 24, Part 6 (Section 140.4).

The primary objective of this code change is to achieve energy savings for large cooling towers. The performance requirement for these towers has changed very little since it was introduced in 1999, and the market has shifted towards more efficient towers. It's been shown to be cost effective to use towers nearly twice as efficient as the mandatory requirement, so this proposal suggests adopting a more stringent requirement. The energy savings and cost-analysis used the large school and large office prototype buildings.

The Statewide CASE Team calculated the first-year statewide energy savings by multiplying the per prototype building savings by the statewide new construction forecast for 2020.

Table 4 Cooling Tower Efficiency Savings

1st Year Electricity Savings	1st Year Peak Electrical Demand Reduction	1st Year Natural Gas Savings	Lifecycle PV Energy Cost Savings
1.5 GWh	1.4 MW	N/A	$5.9 million

Using the results from the prototype models, and given data regarding the new construction forecast for 2020, the Statewide CASE Team estimates that the proposed code change will result in annual statewide electricity savings for new construction of 1.46 GWh with an associated demand reduction of 1.41 MW. The energy savings for buildings constructed in 2020 are associated with a present valued energy cost savings of approximately PV $5.85 million in (discounted) energy costs over the 15-year period of analysis.

DISCUSSION

To assess the energy, demand, and energy cost impacts, the Statewide CASE Team compared current design practices to design practices that would comply with the proposed requirements. Where there is an existing Title 24, Part 6 standard that covers the building system in question, the existing conditions assume the prototype building complies with the 2016 Title 24, Part 6 Standards with the minimal allowable efficiency. Where there is no existing Title 24, Part 6 requirement that covers the building system in question, the Statewide CASE Team used current design practices as the existing condition.

There were challenges in modeling due to limitations in modeling software and the large number of climate zones that had to be analyzed for the state of California.

The Statewide CASE Team was encouraged to use CBECC-com, which was developed by the State, to calculate the first year impacts from the proposal. CBECC-com is commonly used in California to comply with the performance pathway and uses OpenStudio/EnergyPlus to calculated energy use of the proposed and standard design models. The CASE Team received access to the developer module in CBECC-com to unlock the batch processing tool, which can run multiple pre-created files at once. This was necessary when running the prototype models for all 16 California climate zones.

CBECC-com 2016, unfortunately, has limited system options and often lacks the capability to run the systems relevant to the proposed measures. Although some measures, such as the Fan System Power measure, could easily be modeled in CBECC-com by adjusting the static pressure of the proposed model, other proposals, such as the Exhaust Air Heat Recovery measure, were not possible to model in CBECC-com due to the lack of heat recovery ventilator object in the software.

In cases where CBECC-com could not model the proposed code changes, the CASE Team used the modeling capabilities of OpenStudio. CBECC-com generates an OpenStudio .osm file when models are run. By taking the baseline prototype model OpenStudio .osm files and using the OpenStudio Command Line Interface (CLI), the proposed changes were modeled, which provided the opportunity for multiple OpenStudio files to be processed at once. The results of these runs were then post-processed in the same method CBECC-com does in the batch processing tool and the statewide impacts were calculated.

By utilizing the OpenStudio CLI, the CASE Team was able to accurately model the proposed changes and calculate the statewide impact without being limited to the software capabilities of CBECC-com.

Additionally, the writing of the CASE reports required extensive stakeholder input and outreach. Stakeholders were asked for feedback on the proposed 2019 code changes during public stakeholder meetings that were held in September 2016 and March 2017. Further, targeted surveys were sent to different market actors, including mechanical designers, engineers, and contractors to gather thoughts on the code change proposal. In addition, several interim drafts of the CASE report were posted for public comment.

These opportunities for the public to comment often resulted in conflicting interests from stakeholders. A careful balance must be recommended that meets the concerns of the most influential stakeholders while still maximizing energy savings. Some examples of particularly influential stakeholders include state agencies representing special interests, and respected experts in the industry. For example, for the nonresidential indoor air quality measure, it was essential that the California Air Resources Board was satisfied with the proposed code changes; in previous code cycles, a vocal state agency in opposition was enough to derail the measure.

Further, since the Codes & Standards Enhancement initiative is a statewide program sponsored by PG&E, it was crucial that energy savings are maximized; this is because PG&E gets paid according to the savings that are realized from the proposed code changes.

CONCLUSION

Four nonresidential HVAC proposals for the 2019 energy code, ASHRAE 62.1 alignment, ASHRAE 90.1 alignment, cooling tower efficiency requirements, and lab exhaust requirements, were analyzed with respect to market feasibility, energy savings, and cost savings. Each of these measures was found to save the state of California a significant amount of energy, totaling 43.4 GWh of electricity savings and 1.4 million therms of gas savings. Additional, each measure was found to be cost-effective and therefore a worthwhile investment for the state of California. Finally, the challenges of the Codes and Standards Enhancement process, primarily the difficulty in performing large-scale modeling and balancing stakeholder input in a regulatory environment, were examined.

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