From Zero to Hero, How to Get Started with BPS and Comply with Flying Colors

Mazen Daher, Sara Beaini, Siva Sankaranarayanan, EPRI
Randall Higa, Amy Discher, Chris Malotte, Southern California Edison

ABSTRACT

California's Assembly Bill 802 has been in effect since 2015 and has established a statewide building energy benchmarking and public disclosure program. The recently approved Senate Bill 48 may accelerate this effort and California may move toward a statewide building performance standard by leveraging AB 802 benchmarking data. Consequently, building owners and policymakers face growing pressure to identify cost-effective compliance strategies. This paper presents a modeling framework that evaluates a menu of low-carbon retrofit packages for commercial and multifamily buildings, designed to support Building Performance Standard (BPS) compliance and utility planning.

Using EnergyPlus simulations, we describe a methodology for assessing energy upgrade scenarios across representative building prototypes. These scenarios are analyzed through a value-based cost-benefit lens, measuring impacts on energy use intensity, Greenhouse Gas (GHG) emissions, and economic performance under varying regulatory conditions. Two case studies - one looking at multiple building types in one climate zone, and the other at the same building type in multiple climate zones - illustrate the analytical methodology.

Preliminary results reveal how climate zone and building type influence the cost-effectiveness of electrification. Key findings include that there is no one-size-fits-all solution for BPS compliance, that the outcomes of BPS compliance should be viewed from the perspective of various stakeholders, and that California's diversity may pose unique challenges to BPS implementation. Those findings may offer scalable, actionable starting points for BPS programs to guide covered building owners. While focused on California, the approach is transferable to other regions with similar climates. This work supports statewide energy efficiency goals while providing practical tools for navigating the intersection of policy and implementation.

1. Introduction

In October of 2023, California passed Senate Bill 48 (SB 48), the Building Energy Savings Act (California Legislature, 2023). California SB 48 requires the California Energy Commission (CEC) to explore the enactment and implementation of a building performance standard (BPS) throughout the state of California.

Building Performance Standards are ordinances or laws that establish annual energy and/or carbon emission reduction requirements for all existing buildings meeting a certain floor area threshold over a certain timeframe. Those standards are typically enacted following the enactment of a Benchmarking law that requires large buildings to report on their energy use on an annual basis. BPS are directed and may exist at different levels of government. For instance, the cities of Seattle (City of Seattle, 2023) and Chula Vista (City of Chula Vista, 2021) currently have local building performance standards. Various cities in California, including San Francisco, Santa Monica, and Berkeley, have pledged to adopt a BPS (DOE, 2026) in parallel to the State's efforts. Similarly, building performance standards have been adopted at the state level, for example, in Maryland and Washington. This work is motivated by the enactment of a prospective California BPS, and aims to understand the different considerations that building operators may need to consider to sustainably and affordably comply with a BPS in California.

The intent of this project is to understand the implications that the use of different metrics and compliance rules in a prospective BPS would have, including: (1) how a prospective policy would impact utility operations, (2) how utilities or the state should think about the secondary effect of building performance standards and their root causes. A prospective BPS may impact utility operations by driving large, systemwide increases in peak load, for example (Kostic et al., 2024). Secondary effects of a building performance standard, as investigated in this study, may include: Changes in energy costs from fuel switching, especially given that electricity tends to be substantially more expensive than natural gas in California, and an assessment of the most viable/likely courses of action for different building types throughout the state.
Towards this end, the research team is engaged in a project to model energy conservation and electrification measures throughout the state of California to assess the prospective costs and benefits of various compliance measures for different stakeholders involved in the California energy system, including utilities, customers, and society writ large. In more concrete terms, the goal is to understand how customer costs, grid impacts, and emission reductions interact in the context of a BPS across all sixteen California climate zones. As the study is still underway, we limit ourselves in this paper to two illustrative use cases.
This study evaluates the multifaceted implications of Building Performance Standards by shifting the focus from regulatory mandates to operational execution. BPS frameworks typically utilize data-driven, outcome-based targets like Energy Use Intensity (EUI) or Greenhouse Gas (GHG) emission reductions, yet they remain agnostic regarding specific implementation strategies (EPRI, 2023). For example, some jurisdictions have explicit GHG reduction targets for buildings include Seattle (Seattle Office of Sustainability, 2023), New York City (New York City Council, 2019), Maryland (Maryland General Assembly, 2022), and Boston (City of Boston, 2022). Others, such as Washington State (Washington State Department of Commerce, 2024) and Chula Vista (City of Chula Vista, 2021), base their compliance targets on Energy Use Intensity. Consequently, this research investigates the techno-economic implications of various decarbonization measures to identify which interventions offer the greatest strategic advantage across diverse building typologies and determine the factors and characteristics that must be considered.

The primary contribution of this work is a modeling framework designed to operationalize Building Performance Standards (BPS) by identifying the practical implications of compliance. These implications can be thought of through a series of research questions: (a) In an environment that incentivizes electrification, how much peak load growth can be expected, and when?, (b) Will compliance, on the whole, positively or negatively impact customer utility bills?, and (c) Which energy conservation measures provide the best combination of outcomes for all involved stakeholders?

While this paper does not represent the full scope of the study, we showcase two use cases that may be informative to policymakers and utilities, discussing potential electrification/compliance pathways for two buildings in one climate zone, and similarly for one building in multiple climate zones.

This methodology integrates critical technical and economic variables: internal gains, building characteristics, utility demand charges, and market conditions, to simulate realistic energy profiles across all sixteen California climate zones. By mapping these factors to representative building typologies, the research provides a scalable approach to understanding how diverse energy conservation measures perform statewide. While simulation is ongoing, this paper presents illustrative examples that highlight the key value dimensions and stakeholder considerations necessary for a successful transition.

2. Building Performance Standards: Typical Characteristics

Building Performance Standards (BPS) can take different forms. They can typically be classified according to characteristics such as performance metrics, compliance timelines, noncompliance penalties, among others (EPRI, 2023). A significant differentiator between different BPSs is the performance metric used to assess compliance. In terms of compliance metrics, BPSs tend to fall into two categories: those that are based on energy efficiency, through metrics such as Site Energy Use Intensity (corresponding to the total energy use for a given year divided by total floor area), and those that are based on greenhouse gas emissions (most often, scope 1 greenhouse gas emissions i.e. emissions from onsite combustion of fossil fuels, though some standards also incorporate scope 2 emissions i.e. upstream emissions in the energy system from consumption of electricity). Figure 1 is a map developed by Pacific Northwest National Lab (DOE, 2026) that shows all jurisdictions in the United States that have either passed a building performance standard or pledged to adopt a building performance standard. According to the Institute for Market Transformation (Institute for Market Transformation, 2020), if all the jurisdictions that have pledged to adopt a building performance standard were to follow through on that pledge, 25% of the national building stock would be impacted. That portion of commercial buildings covers 74 million people. Given the investments in energy efficiency and electrification upgrades that would be required to comply with these standards, the Institute for Market Transformation anticipates that investments will reach $124 billion in order to comply with those standards (Institute for Market Transformation, 2020). Because many jurisdictions are further along than California in developing these policies, stakeholders can use their experiences to anticipate future requirements and operating conditions. The shared features of building performance standards across the country make it easier to plan ahead with greater confidence.

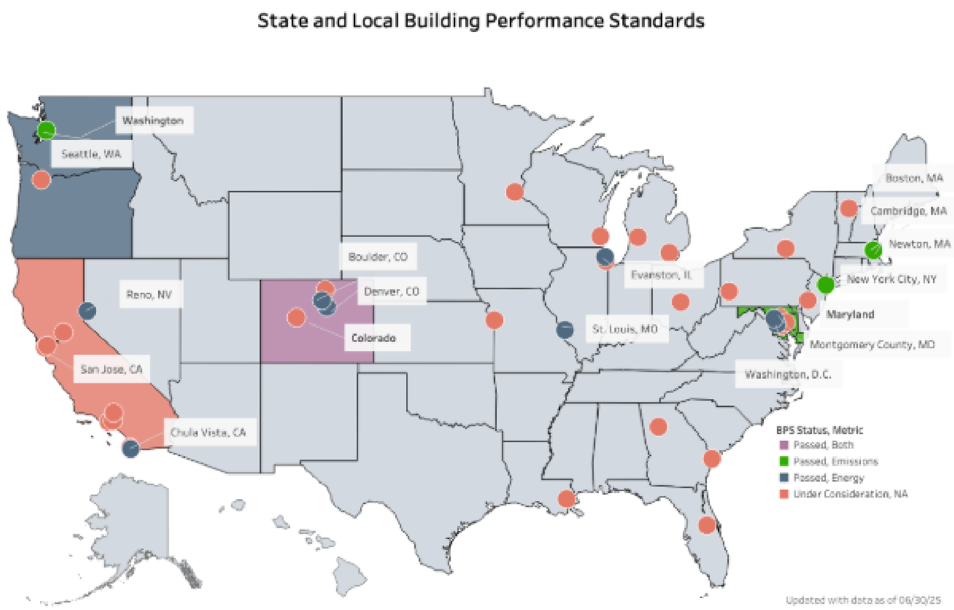

Figure 1 State and Local Building Performance Standards (DOE, 2026)

While many states including California's Title 24 codes have stringent high energy efficiency requirements, code compliance does not automatically imply compliance with BPS. There are a couple of reasons:

1. Timeframe for compliance: Energy codes are typically applied to new buildings and compliance testing is performed at the time of certification for occupancy. Existing buiding stock are not required to comply with energy codes unless explicitly required for a retrofit that is deemed a substantial alteration.
2. BPS compliance is an ongoing peformance requirement that is subject to reporting and penalties (wherever applicable) on an annual basis.

California represents a particularly important case study for building performance standards due to the scale and diversity of its building stock, climate conditions, utility landscape, and policy objectives. If it were to move forward with adopting a BPS, California would be the largest jurisdiction to do so. The state's 16 climate zones span a wide range of heating and cooling conditions, from mild coastal regions to hot inland valleys and mountainous areas, creating substantial variation in building energy use and electrification outcomes. California also exhibits significant diversity in utility service territories, electricity rates, and rate structures, which can materially influence the costs and benefits associated with building decarbonization measures. At the same time, the state faces persistent energy affordability challenges, making it essential to understand not only the emissions impacts of building performance standards but also their potential economic implications for building owners and occupants. As a result, California provides a valuable setting for evaluating how building performance standards may perform across a broad range of real-world conditions and stakeholder contexts.

3. Modeling Methodology

3.1 End Use Value Assessment

This analysis utilizes the End-Use Value Assessment (EVA), a streamlined three-step strategy developed by EPRI to evaluate decarbonization pathways:

(a) **Value Assessment Customization:** The initial phase involves reviewing operational practices to identify critical building segments, typologies, and energy conservation measures (ECMs) aligned with specific objectives. For example, if the primary goal is the reduction of Scope 1 emissions, electrification measures are prioritized as the most effective strategy for mitigating on-site emissions in residential and commercial buildings.

(b) **Building Energy Modeling:** Following the identification of target building types and measures, energy modeling is conducted based on realistic customer adoption scenarios. This step quantifies impacts across various performance metrics to ensure data-driven results.

(c) **Optimal Choice Identification:** The final phase involves generating a prioritized list of interventions for different stakeholder groups. This process identifies compliance pathways that maximize value across all dimensions (described in the discussion of stakeholders in the following section, but understood to include peak load increases from all-electric technologies, changes in customer utility costs in light of electrification, and societal considerations such as greenhouse gas emissions and costs to the energy system) while addressing the requirements of all involved parties.

3.2 Primary Stakeholders

The End-Use Value Assessment evaluates impacts across three primary stakeholder groups:

(a) **Electric Utilities:** Utility objectives focus on maintaining grid reliability and deferring capital-intensive infrastructure upgrades where applicable. By mitigating peak load increases, utilities can delay or avoid necessary investments in transformers, substations, and distribution assets. Failure to manage these loads effectively can result in significant upward rate pressure arising from higher investments in the distribution grid

(b) **Customers:** Customer priorities center on minimizing first costs and recurring utility bills and non-compliance penalties. These objectives are addressed by identifying energy-efficient technologies that reduce life-cycle operating costs and by leveraging available financial incentives while achieving the necessary levels of performance. Additionally, customers are sensitive to rate impacts; grid-level infrastructure constraints or inefficient load growth can lead to higher costs per kilowatt or kilowatt-hour for the end user.

(c) **Society:** The societal perspective evaluates broad environmental and policy outcomes. Key metrics considered under the umbrella of societal benefits may include the reduction of greenhouse gas emissions, long-term system cost (LSC, formerly known as Time Dependent Valuation) mitigation (Energy and Environmental Economics, 2016), and compliance with local or state Building Performance Standards. Furthermore, this perspective assesses the extent to which building-level interventions advance city-wide climate action plans.

3.3 Building Types under Consideration

The broader analysis utilizes a diverse range of building types, shown in Table 1. These were modeled using Department of Energy (DOE) standard building prototypes as established baseline representatives of the California building stock (Deru et al., 2011). While not all of those are discussed in the present paper, their inclusion is helpful for underlining which buildings may need support in complying with a BPS.

Table 1 Buildings under Consideration

Building Type	**Floor Area**	**HVAC System**
Hospital	241,351	Hydronic
Large Hotel	122,120	Hydronic
Large Office	498,588	Hydronic
Restaurant	5,500	Packaged Units
Secondary School	210,887	Hydronic

The selection process was guided by several critical factors:

(a) **Regulatory Thresholds:** Most selected types typically exceed the 20,000 or 50,000 square foot thresholds commonly used to trigger compliance with Building Performance Standards. While smaller retail or dining facilities may be exempt, large-scale assets like hospitals and hotels are primary targets for regulation.

(b) **Vintage and Compliance Variability:** Because Title 24 requirements have evolved without retrospective enforcement, the existing building stock exhibits significant performance variability. DOE prototypes, informed by existing building reports from prior codes and standards research, provide a foundational data set to capture this diversity across all California climate zones.

(c) **Sector-Specific Challenges:** Although few standalone restaurants meet the square footage requirements for BPS, the restaurant broadly represent commercial kitchens that are part of the food services building segment.

3.4 Energy Conservation Measures under Consideration

The analysis evaluates three specific energy conservation measures categorized into two primary strategies: electrification and weatherization. These measures were selected to investigate their individual performance and their synergistic effects on building efficiency. These measures are further described in Table 2.

(a) **Electrification:** This strategy focuses on the replacement of legacy natural gas-fired equipment with high-efficiency heat pump technologies. The modeling utilizes typical coefficients of performance (COP) and standard efficiency ratings to quantify the transition from fossil fuel combustion to electric-driven thermal systems. For those systems, equipment assumptions are derived from a concurrent EPRI study (EPRI, 2025).

(b) **Advanced Weatherization:** The study examines the implementation of "snap-on" window insulation panels designed to enhance the thermal resistance of the building envelope. This measure improves thermal retention during the heating season and reduces solar heat gain during the cooling season. Unlike traditional envelope retrofits, which are often cost-prohibitive for large commercial assets, the selected window insulation panels represent a low-first-cost alternative. These panels are under study in a California Energy Commission-funded project led by EPRI (Energize Innovation Fund, 2026) and are part of the CalMTA Commercial Replacement and Attachment Window Solutions (CRAWS) Market Transformation Initiative[1].

Table 2 List of Energy Conservation Measures Under Consideration

Category	Measure	Description
Electrification	Water Heating	Replaced gas water heaters with heat pump water heaters with a coefficient of performance (COP) of 3.0.
Electrification	Space Heating (Hydronic Buildings)	Replaced boilers with an air-to-water heat pump plant loop for hydronic buildings, with a COP of 3.5.
Electrification	Space Heating (Non-Hydronic Buildings)	Replaced gas packaged rooftop units (RTUs) with air-source heat pumps.
Weatherization	Window Retrofit	Added snap-on window insulation panels to reduce solar heat gain (SHG) and increase thermal insulation at the window. The intent is to keep heat inside during winter and outside during summer.

Analyzing the interaction between weatherization step electrification strategies is a key component of the study, as integrated approaches may optimize building operation and ease the transition to electric space and water heating systems.

The study evaluates the impact of building interventions across two primary categories: regulatory compliance metrics and techno-economic operational metrics.

(a) **Compliance Metrics:** The analysis focuses on the two primary pillars of BPS frameworks: Energy Use Intensity and Greenhouse Gas emissions. A key objective of this research is to quantify how optimization strategies differ when prioritizing one metric over the other. This includes evaluating the implications of Scope 2 emission targets, addressing the industry debate regarding the fairness of holding building operators accountable for grid-side carbon intensity.

(b) **Customer Economics and Affordability:** Given the recent focus on energy affordability, utility bill impact is a central metric. The study assesses how electrification and weatherization affect monthly operational costs and long-term affordability for the building owner.

(c) **Grid Impact and Peak Demand:** The research examines peak load changes to identify potential threats to grid reliability and the resulting need for infrastructure investment. For the customer, peak demand is a critical cost driver due to the complex demand

[1] Commercial Replacement and Attachment Window Solutions - https://calmta.org/commercial-replacement-attachment-window-solutions/

charges typical of large commercial utility rates. By mitigating peak load, operators can reduce both direct costs and the broader upward rate pressure caused by grid-level capital expenditures.

This paper seeks to showcase the analytical framework described there through two case studies:

(a) Case Study #1: Assessment of two building types in one climate zone.
(b) Case Study #2: Assessment of the hospital prototype across multiple climate zones.

4. Case Study #1: A Tale of Two Buildings

Comparing multiple building types within the same climate zone can provide valuable insights for local jurisdictions considering the development of building performance standards, as an increasing number of California cities are doing. By controlling for climate, such analyses highlight how differences in building characteristics, end-use profiles, and operating patterns influence the costs and emissions impacts of decarbonization measures. These results can help policymakers assess the extent to which building performance targets can be achieved cost-effectively across different segments of the building stock. The comparison may also be useful for utilities and municipalities seeking to identify building types that could face disproportionate compliance costs or technical challenges under a prospective building performance standard and may therefore benefit from targeted programs, incentives, or technical assistance.

4.1 Building Characteristics and Case Study Parameters

To showcase the methodology, we consider the hospital and large office buildings, based on EnergyPlus model prototypes developed by the Department of Energy and representing post-1980 construction. We study those buildings in California Climate Zone 3, with San Francisco as the representative city, subject to Pacific Gas and Electric. For both of those buildings, the applicable PG&E rate is the B-20 rate (PG&E, 2024). This is a time-of-use rate with both facilities-related demand charges (maximum for the month) and time-related demand charges (maximum for the month for a specific period, such as on-peak). We refer the reader to the source in the bibliography for a more detailed description of the rates.

Both buildings have hydronic heating and cooling, meaning that heat is moved through the building using a water loop with a chiller and boiler. Air is provided to the occupied spaces using Variable Air Volume distribution with cooling at a central air handler and reheating at the zone level. Further detail on those buildings can be seen in Table 3.

Table 3 Characteristics of the Two Building Prototypes Under Consideration

Attribute	Hospital	Large Office Building
HVAC System Type	Mixed-fuel hydronic heating and cooling: Chiller/boiler VAV with reheat	Mixed-fuel hydronic heating and cooling: Chiller/boiler VAV with reheat

Main End Uses (California Climate Zone 3)	Heating: 28% Interior Lighting: 20% Interior Equipment: 19%	Interior Lighting: 34% Interior Equipment[2]: 33% Cooling: 8%
Fossil Fuel Loads that may be Electrified (California Climate Zone 3)	28%	9%
Energy Use Intensity	162 kBTU/sqft	48 kBTU/sqft

In terms of end uses, we see that heating, the main electrifiable load, is the main end use in the hospital, accounting for 22% of total load. Equipment loads, which are not relevant to electrification, appear to be the chief driver of energy use in the large office building. The hospital also has a much higher energy use intensity than the office building, indicative of the high heating needs that are dependent upon low-efficiency fossil-fuel heating.

4.2 Building Energy Use Patterns

Figure 2 shows the total energy use for the hospital and large office buildings in California Climate Zone 3 under three different configurations. The portion of the energy use that is already electric is marked in blue, while the portion of the energy use that is fossil fuel and may be electrified is marked in green. It can be seen that a large portion of the total energy use can be reduced through the introduction of more energy efficient heat pump technologies (with a COP of 3.5 compared to an AFUE of less than 1).

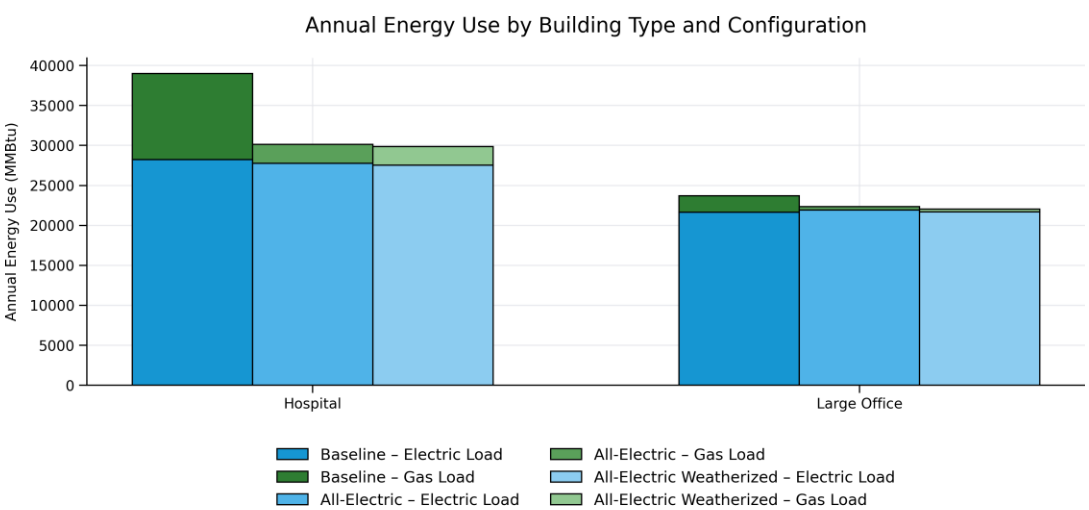

Figure 2 Energy Use Patterns for Hospital

In contrast, Figure 2 shows total energy use for the large office building in the same climate zone under similar configurations. We see that the portion of load that may be reduced through efficient electrification only accounts for 6% of energy use. Therefore, energy efficiency gains

[2] The office has a data center that is modeled as part of Internal Equipment.

are not as readily realizable as they are in the case of the hospital building. Therefore, energy use intensity reductions through electrification may not be realizable for the office building.

4.3 Techno-Economic Analysis

Table 4 shows the results of the techno-economic analysis for the hospital building. Greenhouse gas reductions here refer to scope 1 reductions. The methodology that is implemented is similar to the methodology described in Sheng et al. (2023). We refer to the reader to that prior study for additional information on the methodology.

Table 4 Techno Economic Analysis for Hospital

Upgrade	Lifetime Customer Operating Cost Savings (Relative Savings)	Incremental peak demand (%)	GHG Emissions Reduction (MTCO2e)
HPWH Upgrade	$66,067	0%	222
HPWH+ Space Heating Electrification	$2,632,980	1%	4194
HPWH+Air to Water Heat Pump +Weatherization	$2,918,910	1%	4286

Space heating appears to be the most significant building decarbonization vector. While some peak load exacerbation is observed, the magnitude is not substantial. High electricity costs substantially impede potential savings. Although substantial reductions in Scope 1 and Scope 2 emissions can be achieved, the associated societal benefit must be considered relative to cost for water heating electrification, as fossil fuel use remains a primary driver. Secondary window attachments result in significant improvements in operating cost savings.

Table 5 shows techno-economic analysis results for the office building, with the same assumptions with respect to rates. Like the hospital building, space heating appears to be the most significant building decarbonization vector. Due to the nature of office building load profiles and the high cost of electricity compared to natural gas, energy costs tend not to decrease substantially for this class of buildings. Greenhouse gas emission reductions are present but limited relative to the associated increases in energy costs.

Table 5 Techno Economic Analysis for Office

Choice	Lifetime Customer Operating Cost Savings (Relative Savings)	Incremental peak demand (%)	GHG Emissions Reduction (MTCO2e)
HPWH Upgrade	($82,683)	0%	701

HPWH+ Space Heating Electrification	$809,154	0%	1105
HPWH+Air to Water Heat Pump +Weatherization	$1,105,914	0%	1175

5. Case Study #2: Statewide Deep Dive on Hospitals

5.1 Value of Case Study

Modeling the same building type across multiple climate zones provides a useful case study of how the impacts of electrifying fossil-fuel end uses can vary across California. As the second-largest state in the contiguous United States and home to 16 distinct climate zones, California offers a unique setting for evaluating the implementation of building performance standards. Documenting the range of outcomes across diverse climate conditions and utility service territories can provide valuable insights into the opportunities and challenges associated with statewide electrification efforts.

Beyond informing statewide policy development, understanding how electrification outcomes vary across climate zones is valuable for multiple stakeholder groups. For the California Energy Commission (CEC), these results can support the development and refinement of building performance standards by providing insight into the range of outcomes that may occur across the state. For investor-owned utilities, whose service territories often encompass multiple climate zones, the analysis can help identify region-specific opportunities, challenges, and program impacts. The findings may also be relevant to large portfolio owners, such as national account customers and statewide healthcare systems, which frequently operate similar building types across diverse geographic regions and must evaluate electrification investments under varying climatic, operational, and utility rate conditions.

5.2 Why Hospitals?

Hospitals are a compelling focus because they are widely distributed across the state, spanning multiple locations and climate zones. Their energy characteristics are also uniquely significant, with complex load profiles that include numerous critical systems and intensive ventilation requirements. Additionally, the removal of Health Care Access and Information (HCAI) exemptions in the 2019 Title 24 code cycle[3] further underscores the importance of targeting this sector, as hospitals are now more fully subject to energy performance requirements.

5.3 Case Study Parameters

The hospital building used in this case study has the same characteristics as the building prototype used in the previous case study.

Five climate zones were selected for this case study, to represent a sufficient degree of climate diversity:

- **Climate Zone 3:** mild climate typical of the coastal San Francisco Bay Area. Cities in this climate zone include San Francisco and Oakland. PG&E is assumed to be the electric and gas utility for this climate zone.

[3] Healthcare Exceptions: https://title24stakeholders.com/measures/2028-cycle/healthcare-exceptions/

- **Climate Zone 9:** mild climate typical of the inland Los Angeles Basin. Cities in this climate zone include Burbank, Glendale, and Irwindale. SCE is assumed to be the electric utility and SoCalGas is assumed to be the gas utility.
- **Climate Zone 12:** Hot, dry climate (with substantial winter heating needs) typical of the middle third of the Central Valley. Cities in this climate zone include Sacramento, Stockton, Walnut Creek, and Modesto. PG&E is assumed to be the electric and gas utility for this climate zone.
- **Climate Zone 15**: Desert climate typical of the Colorado Desert of Southern California. Cities in this climate zone include Palm Springs and Indio. SCE is assumed to be the electric utility and SoCalGas is assumed to be the gas utility.
- **Climate Zone 16:** Alpine climate typical of the Sierra Nevada. Cities in this climate zone include South Lake Tahoe and Blue Canyon. PG&E is assumed to be the electric and gas utility for this climate zone.

For climate zones in PG&E service territory, the B-20 time of use rate for large commercial buildings was used to compute electricity costs, in similar fashion to Case Study #1. For those in SCE service territory, Southern California Edison's General Service TOU-8 (Option D) was used (Southern California Edison, 2025). Both of those rates are time-of-use rates with both facilities-related demand charges (maximum for the month) and time-related demand charges (maximum for the month for a specific time period, such as on-peak). We refer the reader to the respective sources in the bibliography for more detailed descriptions of the rates.

Greenhouse gas emissions, both scope 1 and scope 2, are computed according to the methodology developed by E3 for assessing the Title 24 Compliance of modeled energy designs. Scenarios tested for the hospital are the same as those for Case Study #1, albeit in multiple climate zones .

5.4 Results

Figure 3 shows the Energy Use Intensity (EUI) results for three different hospital designs in different climate zones. The designs shown are the Mixed-fuel DOE baseline, the All-Electric Design, and the All-Electric Weatherized Design. The incremental benefit of the tested energy conservation measures ranges from 12% in CZ15 (Palm Springs, the warmest climate zone) to 24% in CZ12 (Sacramento Valley). Large EUI reductions may be challenging for hospitals due to their complex operations, often requiring strategies that go beyond straightforward electrification and weatherization measures. Achieving ambitious reductions may necessitate deeper system-level changes and operational improvements, as certain common retrofit measures, such as window upgrades, tend to have only a marginal impact on overall energy performance in hospital settings. Instead of prescribing a fixed energy use intensity (EUI) target for each building type, some building performance standards, such as the Colorado Building Performance Standard, take a flexible approach by requiring buildings to achieve percentage-based reductions in energy use. Yet even under the Colorado Building Performance Standard's more flexible approach, which requires EUI reductions of 29% by 2030, the designs tested here would fall out of compliance, highlighting the challenges for this sector. Still, we see directionally consistent results across all climate zones.

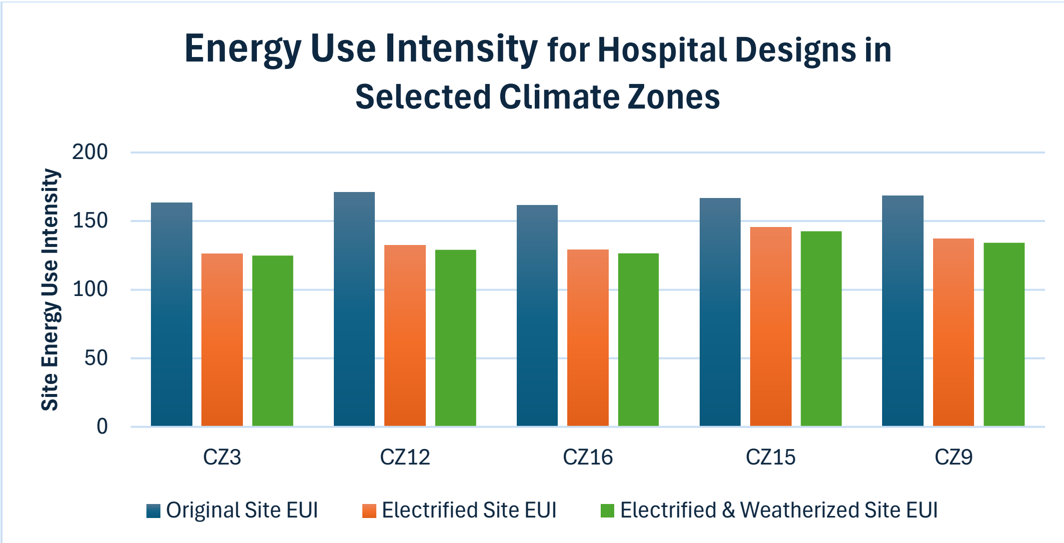

Figure 3 Energy Use Intensity Analysis

Figure 4, showing annual utility cost for the different designs in the climate zones of choice, does not show the same directional alignment. Multiple effects seem to be interacting to produce these divergent cost results, as we see divergent cost outcomes for the two coastal zones (CZ3 and CZ9), positive outcomes in the Central Valley (CZ12), and negative outcomes in both the heating dominated CZ16 and the cooling dominated CZ15. This trend highlights the complexity of assessing customer benefit across climate zones, even for measures that seemingly bolster BPS compliance (through EUI reduction) statewide. It should be noted that these changes in energy costs tend to occur at the margin (as the y-axis is set to a minimum of $1.6M to better show the change in energy costs). While the changes may seem marginal, an increase in energy costs would be detrimental to the lifecycle benefit of the conservation measure, especially given the high first costs associated with commercial building retrofits.

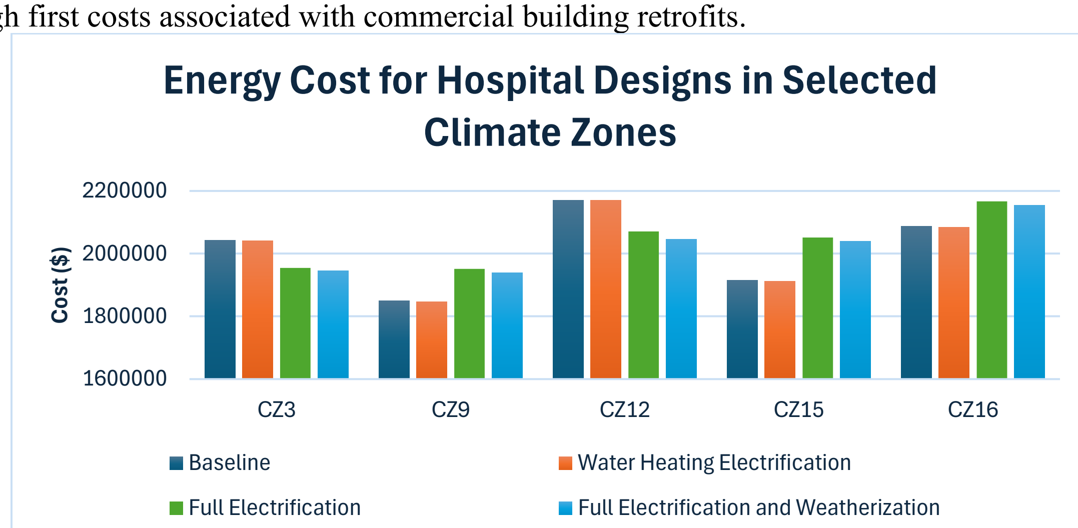

Figure 4 – Comparison of the cost of hospital upgrades across multiple climate zones.

The use of Scope 2 emissions accounting, focused on purchased electricity, can limit the apparent benefits of electrification. In California , the relatively high carbon intensity of the electric grid means that electrification alone may not be sufficient to meet more ambitious emissions reduction goals, especially for complex facilities like hospitals. As a result, deeper efficiency measures and operational changes are likely necessary. Additionally, certain retrofit strategies, such as window upgrades, tend to have only a minimal impact on overall emissions reductions in hospital settings. Figure 5 illustrates this with Scope 1 and 2 reductions across climate zones. On a similar note, the peak loads attributed to various electrification upgrades for hospitals vary by climate zones with milder climate zones showing negligible impact but more intensive cooling-oriented climate zones requiring sharp peak loads increases.

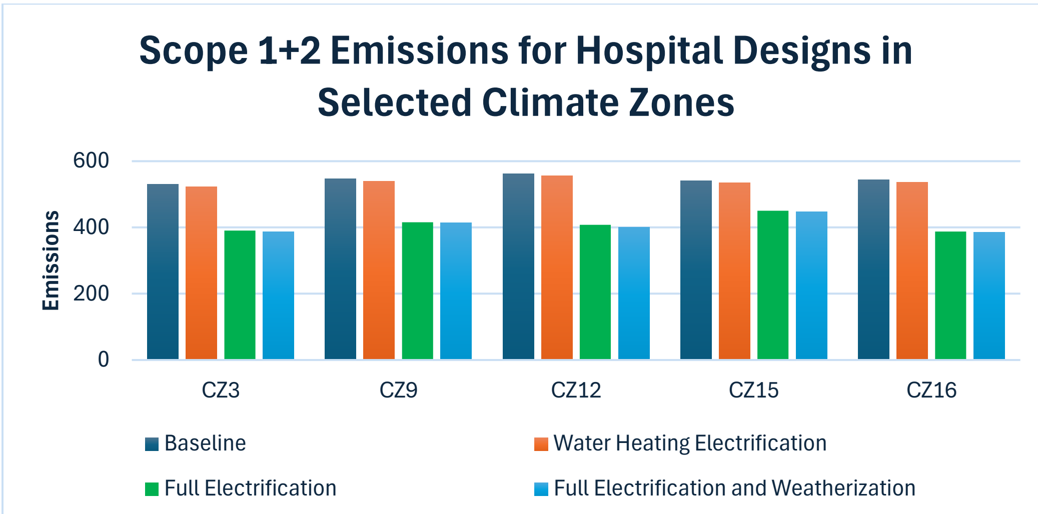

Figure 5 – Comparison of Scope 1+2 emissions reductions for hospitals in various climate zones

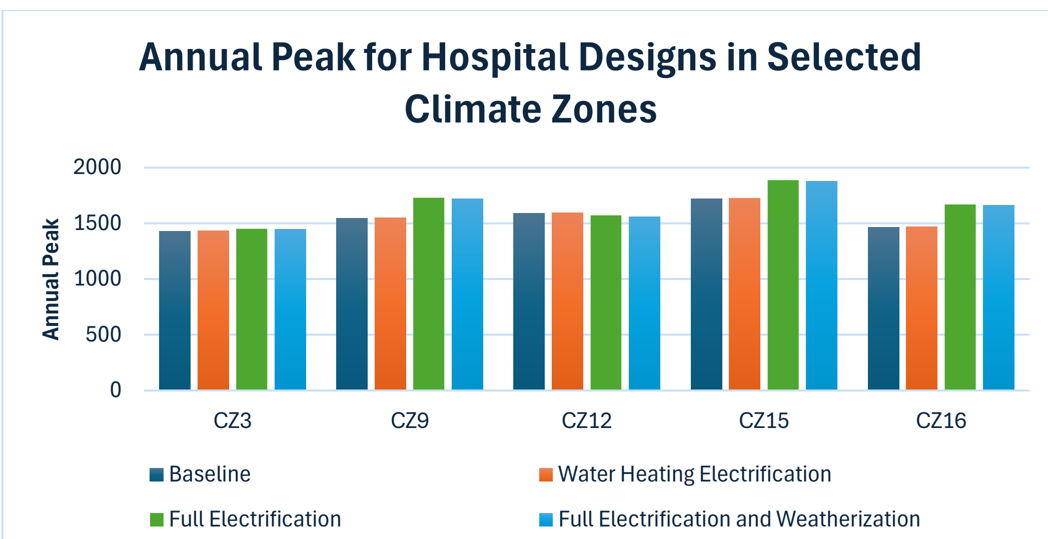

Figure 6 – Comparison of annual peak changes for hospitals in various climate zones

6. Conclusions

The following takeaways can be concluded from the present preliminary case studies:

(a) **There is no one-size-fits-all solution for BPS compliance:** As shown in the two case studies, two buildings can have divergent outcomes when the same energy conservation measures are implemented. In the first case study, while GHG emissions were substantially reduced in both cases, cost outcomes were a mixed bag for the office building, while they were relatively neutral for the hospital. In turn, this identifies hospitals as a priority candidate for electrification-driven BPS compliance compared to large offices in this climate zone. Still, an expansion of hospital modeling to other climate zones revealed more mixed results. The authors are continuing their work, which helps to identify specific climate-zone-specific optimal building typologies for electrification-driven BPS compliance.

(b) **California's geographic, climatic, and economic diversity must be accounted for in a BPS:** A single energy conservation measure may produce substantially different outcomes across climate zones, utility service territories, and building types (or even for the same building type across different climate zones), as observed in the two use cases under discussion in this paper. Policymakers should therefore consider mechanisms that account for regional differences while maintaining statewide decarbonization objectives. While not at the scale that would be required for California, examples of BPS's that try to tackle this diversity, such as the Washington BPS (WA State Dept. of Commerce, 2024), based on ASHRAE Standard 100, exist and have been implemented.

(c) Building performance standard compliance should be evaluated through a multi-stakeholder lens. Compliance outcomes affect building owners, occupants, utilities, regulators, and the electric grid in different ways, as documented through the two case studies. As a result, design of future building performance standards should consider not only emissions reductions, but also energy costs, operational impacts, grid effects, and broader equity and affordability considerations.

References

Energize Innovation Fund. "Cost-Effective Advanced Window Retrofits for Schools." Accessed March 15, 2026. https://www.energizeinnovation.fund/projects/cost-effective-advanced-window-retrofits-schools.

City of Seattle. "Building Emissions Performance Standard." *Seattle Office of Sustainability & Environment*. Accessed June 12, 2026. https://www.seattle.gov/environment/climate-change/buildings-and-energy/building-emissions-performance-standard.

City of Chula Vista, "Building Energy Saving Ordinance | City of Chula Vista." Accessed 2024. City of Chula Vista. https://www.chulavistaca.gov/departments/clean/benchmarking.

City of Boston "Building Emissions Reduction and Disclosure". 2024. Boston.Gov. https://www.boston.gov/departments/environment/berdo

New York City Council. 2019. "Local Law 97 - Sustainable Buildings." April 2019. https://www.nyc.gov/site/sustainablebuildings/ll97/local-law-97.page

Washington D.C. Department of Energy and Environment "Building Energy Performance Standards (BEPS)." Accessed 2024. Washington D.C. Department of Energy and Environment. https://doee.dc.gov/service/building-energy-performance-standards-beps

California Legislature. *SB-48: Building Energy Savings Act*. Chaptered October 7, 2023. https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=202320240SB48.

Developments in Building Performance Standards: Preparing for a data-driven built environment. EPRI, Palo Alto, CA: 2023. 3002026790.

Washington State Department of Commerce “Clean Buildings Performance Standard (CBPS).” 2024. Washington State Department of Commerce. April 10, 2024. https://www.commerce.wa.gov/cbps/
Energy and Environmental Economics, Inc. (E3). 2016. Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2019 Time Dependent Valuation (TDV) Data Sources and Inputs. Prepared for the California Energy Commission. July 2016. https://www.ethree.com/wp-content/uploads/2017/01/TN212524_20160801T120224_2019_TDV_Methodology_Report_7222016.pdf. [ethree.com]

Department of Energy, Building Energy Codes Program. 2026. “State and Local Building Performance Standards.” Tableau.com. 2026. https://public.tableau.com/app/profile/doebecp/viz/BuildingPerformanceStandards/BuildingPerformanceStandards

Electric Power Research Institute (EPRI). *Where are Today's Residential Heat Pump Technologies Cost-Effective?*. Palo Alto, CA: EPRI. 2025 https://www.epri.com/research/programs/063638/results/3002032350
Sheng, Maggie, Siva Sankaranaryanan, Madeline Kostic "A Framework for Evaluating Pathways to Building Decarbonization: Case Study in Seattle City Light." ASHRAE Annual Conference (2023).
CUNY BPL Training. “CUNY BPL Presents: How LL97 Will Impact NYC Buildings.” *CUNY BPL Training*, November 1, 2024. https://cunybpltraining.org/2024/11/01/cuny-bpl-presents-how-ll97-will-impact-nyc-buildings/.
Deru, Michael, Kristin Field, Daniel Studer, Kyle Benne, Brent Griffith, Paul Torcellini, Bing Liu et al. "US Department of Energy commercial reference building models of the national building stock." (2011): 1.
Pacific Gas and Electric Company. *Electric Schedule B-20: Service to Customers with Maximum Demands of 1000 Kilowatts or More*. Revised Cal. P.U.C. Sheet No. 57687-E. March 8, 2024. https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_B-20.pdf
Institute for Market Transformation. “Building Performance Standards Are a Powerful New Tool in the Fight Against Climate Change.” *Institute for Market Transformation*. Accessed June 12, 2026. https://imt.org/resources/building-performance-standards-are-a-powerful-new-tool-in-the-fight-against-climate-change/.
Southern California Edison. *TOU-8 Rate Fact Sheet*. M2025. https://www.sce.com/sites/default/files/custom-files/TOU-8%20Rate%20Fact%20Sheet%200521_WCAG.pdf.

AI Disclosure

AI-assisted tools used: Copilot, Gemini.
Used for: Copy Editing, Voice to Text Transcription, Table Formatting.
Human review: The authors reviewed and verified all content, calculations, and citations.