

Future of the California Energy Code: Where Do We Go After 2022?

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ABSTRACT

The 2022 energy code—Title 24, Part 6—made huge strides towards California’s 2030 goals of achieving a net zero carbon energy code by 2030. The new code incorporates heat pumps for single zone systems in nonresidential and multifamily buildings, requires photovoltaic (PV) and battery systems, and also added a number of energy efficiency and process load measures. Finally, a source energy metric was incorporated into compliance calculations, which aligns the energy code with the state’s greenhouse gas emissions goals. A building using the performance path will have to meet both the time dependent valuation (TDV) metric and the source energy metric. These changes have moved California significantly closer to achieving its 2030 decarbonization and electrification goals.

Moving towards to 2030, what are the primary changes that provide maximum alignment with the state’s goals while minimizing disruptions to the market? In this paper we will review California’s statutes and goals, describe the challenges towards achieving those goals and statutes, and evaluate a number of potential changes to the energy code including the two metric approach, its benefits and limitations; alignment with national model codes, both for prescriptive and performance approaches; improvements to the performance path compliance, such as allowing third-party verification; and finally, increasing the PV and battery requirements to achieve the net zero carbon building..

Introduction

The California Energy Commission (CEC) updates the energy code every three years and adopted the 2022 Building Energy Efficiency Standards (Title 24, Parts 1 and 6, henceforth referred to as the “energy code”) on August 11, 2021 (CEC 2021). This new code edition includes several highly impactful code changes that lead California down the path of building decarbonization and electric grid harmonization. First, it requires heat pumps to be installed in single zone systems for most nonresidential and multifamily buildings in a majority of climate zones and for single-family buildings in a few climate zones. Second, it requires photovoltaic (PV) and battery systems to be installed for most nonresidential and multifamily buildings (single family buildings were required to install PV in the 2019 Energy Code). These two changes constitute a deep reduction (CEC 2021) in the greenhouse gas (GHG) emissions from newly constructed buildings. Grid harmonization was encouraged by limiting on-site renewable energy exports to the grid and encouraging self-utilization. Also, demand response provisions were expanded to for greater load flexibility in response to grid conditions.

In addition to the changes stated above, the CEC developed an hourly source energy (HSE) metric for use in the performance compliance path together with the time dependent valuation (TDV) metric (Sontag, et al. 2020). Thus, a building using the performance path option must now meet both the TDV and the HSE metric to be compliant with the energy code. The HSE metric provides a signal for decarbonization measures, whereas the TDV metric serves as a proxy for cost and also protects the long-life (energy efficiency) envelope measures from being

traded off. Together, the two metrics provide an optimized mix of signals desired by the CEC to achieve its building decarbonization and energy efficiency goals.

The 2022 energy code also increased the energy efficiency of buildings through the addition of a number of energy efficiency and process load measures (CEC 2021). Finally, to address the fastest growing buildings sector in California, the multifamily sector, a new section was created in the energy code that is dedicated to multifamily buildings. These changes have moved California significantly closer to achieving its decarbonization and electrification goals.

California's Statutes and Goals

California has been at the forefront of the energy efficiency and renewable energy industry since the 1970s. It has the distinction of enacting and enforcing one of the country's first energy codes in 1975 (CEC 2022). Throughout the intervening decades, the California legislature has enacted laws that have then been implemented by the CEC. The laws are interpreted by the CEC resulting in the setting of goals and targets and then followed by actions that achieve the goals. As is evident from the discussion that follows, CEC's goals are much more malleable than state statutes, and can be amended to achieve certain policy objectives.

The Integrated Energy Policy Report (IEPR) of 2021 (CEC 2022) provides a summary of the California laws that impact buildings:

- Senate Bill 350 (De León, Chapter 547, Statutes of 2015) requires California to procure 50 percent of energy from renewable energy sources, double energy efficiency savings in electricity and gas end uses by 2030, and study barriers to energy efficiency and clean energy for low-income customers and disadvantaged communities.
- Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) amended the Global Warming Solutions Act of 2006 and called for a statewide reduction of GHG emissions of 40 percent below 1990 levels by 2030.
- Senate Bill 100 (De León, Chapter 312, Statutes of 2018) increased California's Renewables Portfolio Standard (RPS)^{1,2} to 50 percent by 2025 and 60 percent by 2030. The bill requires eligible renewable resources³ and zero-carbon resources to supply 100 percent of retail sales⁴ of electricity to end-use customers and 100 percent of electricity procured to serve all state agencies by December 31, 2045.
- Assembly Bill 3232 (Friedman, Chapter 373, Statutes of 2018) required the CEC to assess the potential to reduce GHG emissions from homes and businesses by at least 40 percent of 1990 levels by 2030. The CEC published an assessment of the potential reduction pathways and associated barriers in August 2021.

Other than the statutes listed above, two significant Executive Orders from the Governor's Office will also play a role in CEC's actions over the next few code cycles:

¹ Renewable Portfolio Standard: <https://www.energy.ca.gov/programs-and-topics/programs/renewables-portfolio-standard>

² Does not include large hydro generation.

³ SB 100 does allow large hydro to be counted in the 100% (unlike the RPS, which excludes large hydro and behind the meter solar).

⁴ Transmission and distribution (T&D) losses (say, 10%) could be made up by gas turbines.

- Executive Order B-55-1818 established a statewide goal to achieve carbon neutrality no later than 2045 and maintain net negative emissions thereafter.
- Executive Order N-79-20 calls for elimination of new internal combustion passenger vehicles by 2035, meaning that all new passenger vehicles sold in California after 2035 will be electric.

The CEC set about implementing these laws and executive orders by targeting energy efficiency, peak demand, and GHG emissions in buildings. It set itself the goals of zero net energy in residential and nonresidential buildings by 2020 and 2030, respectively. Since these zero net energy goals were laid down, it has become increasingly critical to manage the supply of renewable energy on the grid and especially the oversupply during the middle of the day. As a result, the CEC's goals have transitioned from zero net energy—which would have required large amounts of PV on buildings, further aggravating the problem of oversupply—to zero net carbon, which aligns with the state statutes and provides grid harmonization.

Challenges Through 2030 and Beyond

With the PV and heat pump space and water heating requirements in the 2022 code cycle, newly constructed buildings are well on their way to decarbonization. However, several challenges lie ahead, both, in the short-term and in the long-term.

Short-Term Challenges

1. **Real-World Test of The Two Metric Approach:** The two metric approach that was developed for the 2022 energy code is unprecedented (Sontag, et al. 2020). Neither the national model codes (ASHRAE Standard 90.1 and the International Energy Conservation Code) (ASHRAE 2019) (ICC 2021) nor past California energy codes have employed two metrics for determining compliance (Athalye, Higa and Vicent 2020). This novel approach underwent rigorous testing using prototype building models and various scenarios (Hedrick 2020). However, it remains to be seen how difficult or easy it will be for real-world buildings, and in particular, all-electric designs, to meet the code. Certainly, following the prescriptive approach for simple buildings with single-zone systems could be deemed 'straightforward.' However, other complex systems that normally use the performance path may need to use a trial-and-error method because, while the HSE metric credits technologies based on their fuel source and energy efficiency, the TDV metric credits technologies primarily on retail energy costs. It remains to be seen how these signals will couple in the real world and which combination of measures will be effective at meeting the energy cost (TDV), peak demand (TDV), energy consumption (TDV and HSE), and source energy limits imposed by the two metrics. In the upcoming code cycles, small tweaks may be needed to ensure smooth functioning of the two metric approach.
2. **Complex HVAC System Decarbonization Limits:** There are two main limits to decarbonization of complex HVAC systems: the first is operational cost (gas is cheap) and second is showing cost-effectiveness of the relatively new heat pump-based systems. During the development of the 2022 energy code, it was found that HVAC systems

(Hedrick, Shadd and Athalye, Title 24 2022 ACM: Heat Pump Baseline Analysis -- Nonresidential Buildings 2020) with hydronic loops and terminal equipment (such as a built-up VAV system with terminal reheat supplied by hot water from a gas boiler and chilled water by a chiller) consumed less TDV energy than comparable heat pump systems. Heat pump boilers and water loop heat pumps combined with efficient ventilation systems may yet deliver the benefits needed, and more research is needed to demonstrate the effectiveness of those systems. Even if these systems are shown to reduce the annual energy cost compared to fossil-fuel based systems, it remains to be seen whether the heat pump-based systems will be cost-effective.

In recent energy modeling and cost analyses of high-rise and mid-rise multifamily buildings (performed for CEC's Building Initiative for Low-Emissions Development (BUILD) Program) showed that even with highly efficient space and water heating heat pump systems, incentives were needed to achieve (operational) cost parity with traditional HVAC systems. This reality was borne out in similar analyses that the authors have performed for other states (New York) and jurisdictions (Denver, CO), the common factor being the disparity in natural gas and electricity prices in those jurisdictions. This problem is exacerbated in commercial buildings as more heating is required to offset the significant reductions in lighting power densities and controls to further reduce lighting energy use. In addition, more efficient plug loads emit less heat that must be made up by the building's heating system.

Lastly, predictions of advanced heat pump performance have not fully kept up with the technology and applications advancements. Actual part-load performance is improving but the ability of the energy simulation tools in the compliance software has not been able to fully capture these advancements. In most cases, heat or enthalpy recovery systems can save energy, but further market transformation actions are necessary to improve cost-effectiveness.

3. **Embodied Energy Accounting:** The 2021 IEPR (CEC 2022) dedicates an entire chapter to embodied carbon⁵ and makes it a priority for the CEC. The IEPR also describes the current policy landscape, challenges, and opportunities surrounding embodied carbon. The Buy Clean California Act⁶ (BCCA) establishes embodied carbon emissions limits for construction materials procured by the state for public construction projects. Green building rating systems have taken the lead to addressing these issues. While several avenues exist to address embodied carbon, the most crucial and near-term challenge is incorporating embodied carbon accounting into the code development, adoption, and compliance processes. This would involve setting up an embodied carbon budget and then providing the framework to determine the impact of measures on embodied carbon. The embodied carbon impact of energy efficiency measures may be small relative to the impact of structural building components, but it may be comparable to the benefit accrued from the measure over time. Thus, the accounting must focus on the incremental benefit and penalty imposed by the new measures.

⁵ The IEPR describes embodied carbon as the GHG emissions resulting from the extraction, manufacturing, transportation, installation, maintenance, and disposal of building materials.

⁶ The BCCA targets carbon emissions from steel, concrete, flat glass, and mineral board insulation.

4. **Electric Vehicle (EV) Consumption Accounting:** EV supply equipment (EVSE) and EV-capable parking spaces are now required by the California Green Building Standards Code (CALGreen), Title 24, Part 11, (BSC 2019) for single-family and multifamily buildings. The need to incorporate EV requirements within the energy code keeps growing. To date, all the energy coming to the building, either from the grid or generated on site, is accounted in the compliance calculation. EVs pose a unique challenge in that the energy provided to an EV from a building will not be used “on site.” Further, it is easy to envision a scenario where the EV is charged at the workplace during the day and then plugged into the home at night to reduce peak demand for the home. In such a scenario, it is very difficult to attribute the costs and benefits to different grid participants. Another plausible scenario is a “passive house” style home that has a very small or no PV system at all and the EV charging occurring during peak grid demand hours in the evening. In this case, should the house design be penalized for consuming energy during peak hours? Should the EV energy be excluded from the compliance calculation? What incentives (perverse or otherwise) does this create?

It is also challenging to ascertain the value provided by an EV space and charger because EVs replace gasoline consumption. The traditional boundaries of building energy consumption must be expanded to provide a proper accounting of EVs during energy code compliance. A code compliance framework is needed that incorporates the impact of EVs on the building and supports California’s long-term goal of transitioning away from gasoline vehicles to EVs.

5. **Knowledge Gaps:**

- a. **Heat Pump Market:** Despite heat pump water heaters being one of the compliance options for low-rise and single-family buildings in the 2019 Energy Code’s prescriptive path, there is very little market uptake of these systems— less than 6% as of 2021 in the new construction market (CEC 2021) (Delforge 2020). In the 2021 IEPR, the CEC recommends a goal of installing six million heat pumps in new and existing buildings by 2030 (CEC 2022). The new heat pump requirements for space and water heating in the 2022 energy code will certainly expand the heat pump market. However, the market has not caught up with demand and product availability and options remain low. As manufacturers ramp up to meet this new demand in California, the global slowdown in manufacturing and other geopolitical events may mean that market availability of heat pumps continues to be a challenge in the short term. Lastly, there aren’t many options for providing 180F water for dishwashing and sanitary uses in nonresidential buildings.
- b. **Heat Pump Modeling:** There is very little data on how heat pumps operate in the field under various load and weather conditions and because of this paucity of data, energy models lack the basis for accurately representing performance. Advanced heat pump systems, such as heat recovery chillers and heat pump boilers have almost no modeling guidance. Another issue is the lack of a standard governing cold climate heat pump specification, though this is less of a challenge in California given the mild heating season in most locations within the state.

- c. **Distributed Energy Resources (DERs):** While building energy modeling and grid modeling provide a reasonable picture of the impact of building decarbonization under various scenarios, there is not enough information on how decarbonized buildings operate in the real world. The impact of heat pumps is relatively straightforward to model because the system response is 100% load-based (though there are limits identified above); however, other technologies such as batteries, PVs, thermal storage systems (including TES and HPWHs), EVs, and demand response technologies are far less predictable because these technologies can be operated based on different principles. For example, batteries could be operated to minimize the energy cost to the building owner, or to minimize the site carbon emissions, or the source carbon emissions, or to minimize peak demand. All these control principles are quite plausible and, for the most part, not regulated by the energy code. It becomes exponentially more complex to model and predict the behavior of thousands of buildings, residential and nonresidential, and how they will react to future price and market signals. This is likely to be a short-term challenge because, as more decarbonized buildings join the grid, the picture will likely get clearer.
- 6. **Future Weather Data:** There is a large amount of literature on future weather data and generating future weather data is certainly not an issue. The challenge is incorporating this data into the energy accounting methodology for code development. Currently, the energy code uses historical data, but will consider how forecasted weather data may be incorporated. At the start of each code cycle, the TDV and HSE factors are calculated for each climate zone and for the nonresidential and residential building sectors. Weather data feeds into this model and the factors are coupled to the weather data through the projected loads implied by the weather. Forward-looking weather data will result in different TDV and HSE factors and may yield greater opportunity for energy efficiency, decarbonization, generation, and demand response measures. However, these impacts are interrelated and must be thoroughly evaluated prior to the use of forward-looking weather. For example, the cost-effectiveness of current envelope requirements may be different under future weather scenarios.

Long-Term Challenges

1. **Technology limits.** Heat pumps are an “old” technology, but they have yet to achieve significant market penetration and have insufficient volume for the costs to come down. In addition, there may not be much potential to further improve at least the full-load efficiency of heat pumps. Figure 1 shows the potential for commercial HVAC equipment efficiency improvements as it relates to the overall progress required from ASHRAE Standard 90.1 (ASHRAE 2019). As can be seen, marginal gains could be made in part-load efficiency, yet there is a significant gap between where the energy code needs to go and how far HVAC equipment efficiency is able to contribute to the needed improvement.

Commercial HVAC Efficiency Requirements

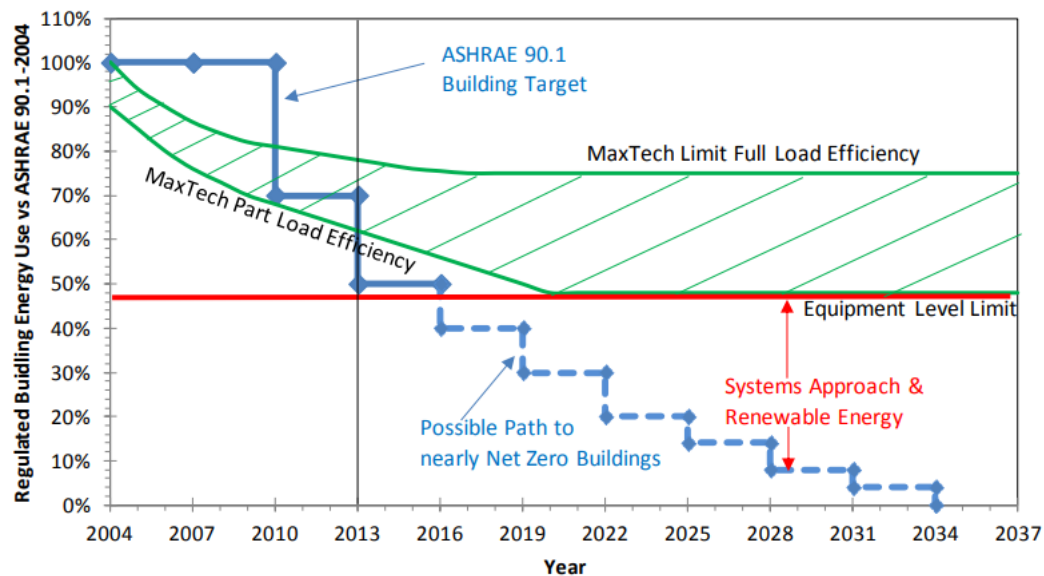


Figure 1: Commercial HVAC equipment efficiency limits and the relationship to energy code target reductions over time. Source: Richard Lord, Carrier, personal correspondence.

2. **Energy Code Limits:** The energy code is governed by certain requirements, most importantly, the Warren-Alquist Act (CEC 2022), that requires “continuous improvements” by requiring updates every 3 years that includes the introduction of new cost-effective measures. This has been evaluated and will likely continue to be evaluated using the TDV metric. Certain decarbonization measures and technologies will come up against this limit. This is nothing new—the energy code has always been at the end of the technology maturation cycle, where a new technology emerges, becomes technically feasible through research and demonstration, goes through the market transformation process, and finally becomes part of the minimum code once it has reached an acceptable level of market penetration.
3. **Fuel prices.** The retail price of gas is a significant barrier because it can be up to 6 times cheaper than electricity (on a kBtu basis). Figure 2 shows the comparison between the price paid by commercial customers in California since 1990 when using electricity (heat pump) and natural gas for heating. The graph includes the price of electricity and natural gas, as well as the efficiency of the heating equipment, and is thus the price paid for a Btu of delivered heat. An average heating COP of 2.0 is assumed for the heat pump, and an efficiency of 0.8 is assumed for natural gas heating. It can take a heat pump heating COP of 6.0 or higher to make up the price difference. This technology simply doesn’t exist yet. The energy code design will also be a key factor in the long run. Combining flexibility (to provide room for innovation) with simplicity (to keep costs manageable) while driving energy efficiency and decarbonization will continue to be a challenge.

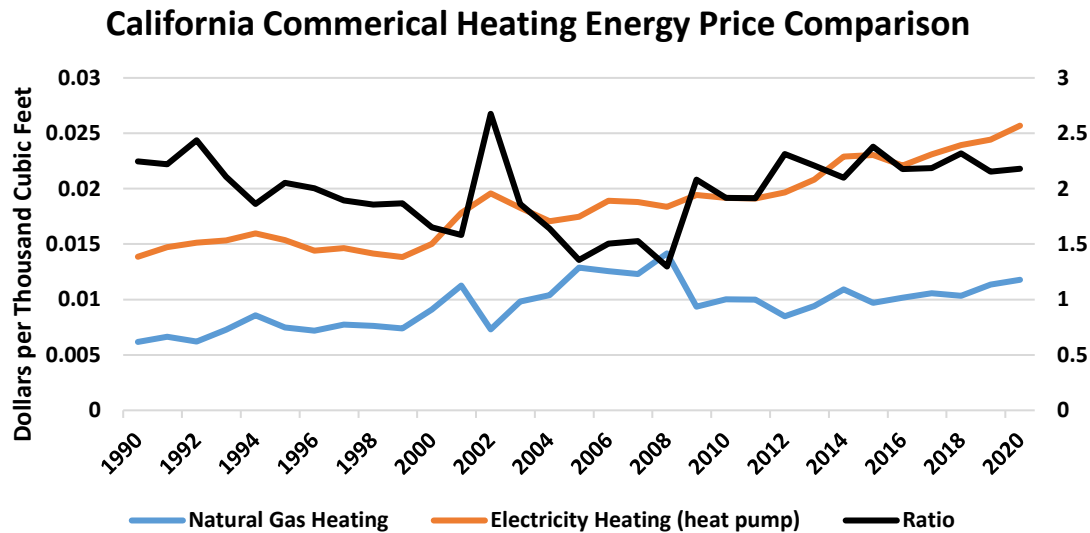


Figure 2: Comparison between electricity (heat pump, assumed 2.0 average heating COP) and natural gas (assumed 0.8) heating price for commercial buildings in California since 1990. Source: underlying energy price data from Energy Information Administration (EIA).

4. **Bridging the Asset and Operating Ratings Gap:** The energy code mainly provides a rating of the assets of the building but does not prescribe budgets for the actual “real world” operation of the building. When a newly constructed building becomes an existing building on Day 1 of its operation, there is no agreed upon standard governing its performance. Building Performance Standards (BPS) attempt to fill this gap by creating a stepped regimen of performance to help existing buildings achieve their energy efficiency potential. Indeed, the 2021 IEPR recognizes the importance of a California-wide BPS (CEC 2022): *“California is in a prime position to implement and enforce a building performance standard using the numerous local, state, and national examples. The CEC acknowledges there is a disconnect between the metrics required to show compliance for new buildings versus existing buildings. The CEC will aim to create a building performance standard with metrics for existing buildings that align with new building metrics using data from utility interval meters, the statewide building benchmarking program, and HERS compliance reports. The goals of the new metric will be to show new and existing buildings on the same spectrum of performance and support energy modeling used in developing building standards, forecasts, and programs.”* With stock turnover, and more of the existing stock becoming decarbonized, it will be important to ensure that the operational performance is properly governed and is achieving the state’s objectives. A statewide BPS will provide this solution.
5. **Automation Limits:** The story of defeated or malfunctioning occupancy sensor controls is oft repeated. Smart devices (thermostats, lamps, luminaires, occupancy sensors, etc.) are intended to take the human element out of the energy efficiency equation and yet, they can have the opposite effect on realized energy savings. DERs, EVs, and other demand response technologies can be operated to serve myriad objectives, only some of

which align with the intent of the energy code. While the goal of automation within buildings is to improve comfort and increase efficiency, the assumptions made through the code development process must be carefully vetted to budget for unintended consequences. The vetting process will be increasingly difficult as the number of DERs increase and the interactive effects vary with the overall intent of the building operation and code requirements (annual energy use reduction, peak demand reduction, self-utilization of onsite renewable energy, GHG reduction from the building, GHG reduction from the grid, grid harmonization, bill reduction, etc.).

6. **Alignment with National Model Codes:** California has been a trend-setter when it comes to energy efficiency and is far ahead of the rest of the country when comes to implementation of heat pumps and renewable generation in the energy code. There is no apparent need for national alignment. Past determination analyses have shown that Title 24 is at least as stringent as Standard 90.1 (ASHRAE 2019). The challenges of energy generation, price, weather, building load, and demographics will always be local to California. However, in some instances, particularly in the performance compliance, it may be useful to align with the national model codes, where system performance approaches are being explored.

Towards the 2025 and 2028 Energy Codes

Narrowing the focus to the 2025 and 2028 energy codes and given the above set of challenges, what should be the immediate focus of the energy code? The 2021 IEPR states that building decarbonization will be achieved through a combination of energy efficiency, renewable generation (utility and distributed generation) and DERs (rooftop solar and batteries), electrification of building end-uses, low-carbon global warming potential (GWP) refrigerants, demand flexibility, and reducing embodied carbon. Some of these pillars of building decarbonization were already being erected through the 2022 energy code. Here are recommended actions for the 2025 and 2028 code cycles that will further building decarbonization through the energy code:

1. **Energy Efficiency:** Most of the cost-effective energy efficiency measures have already been incorporated in the past three to four code cycles. Improvements to existing requirements are still achievable, however, the biggest gains will be achieved through structural changes to the code. These structural changes approaches are discussed further below and a few specific recommendations are provided here:
 - a. **Envelope:** Tighten air leakage requirements for residential and nonresidential buildings. Provide fenestration budgets that incorporate the impact of both glass area and U-factor. Passive house practices have proven that more efficiency can be achieved but further market transformation actions are necessary to improve cost-effectiveness.
 - b. **Lighting:** Ensure improvements in LED efficacy is factored into lighting power allowances. Provide trade-offs between complex lighting controls and lighting power to simplify the energy code. Enhance existing trade-off approaches within the performance compliance software and explore system performance approaches for lighting.

- c. HVAC: Develop an HVAC system performance approach so that heat pump technologies can be expanded to complex system types and the efficiency of *all* HVAC systems is improved. In addition, predictions of advanced heat pump performance have not fully kept up with the technology and applications advancements. Actual part-load performance is improving but the ability of the energy simulation tools in the compliance software has not been able to fully capture these advancements. VRF systems that are an alternative for new or renovated buildings to built-up VAV systems where the problem is that VRF system energy performance is not fully understood and difficult to accurately model.
 - d. Plug and process loads: Continue to tighten controlled environmental horticulture (CEH) requirements.
- 2. **DERs:** Ensure that the PV and battery requirements introduced in the 2022 energy code continue to achieve the intended objectives in light of updated TDV and HSE factors and new weather data. Look for avenues strengthen the PV and battery requirements by basing the requirement on space type rather than building type. This would make nearly all building types require some amount of PV and related the PV size more directly to the spaces their proportions found in the building instead of basing it on the prototype model space mix.
- 3. **Electrification of Space and Water Heating:** Evaluate heat pump boilers and other novel heat pump technologies to determine feasibility in terms of TDV and source energy. Investigate system performance approaches to achieve electrification and energy efficiency objectives (for example, combining other measures, such as fan power, efficient ventilation with DOAS, etc., with heat pump requirements). Also investigate packaging heat pump measures with other requirements, such as PV and battery, to improve cost-effectiveness. Study the heat pump market for costs and availability and improve upon existing heat pump space and water heating requirements. Gather data on heat pump operation in real buildings to inform building energy models and to more accurately characterize heat pump performance.
- 4. **Embodied Energy Accounting:** Develop the framework for accounting embodied energy or carbon in the code development and compliance processes. Currently, there is no standard method to account for the embodied energy of a code change, nor is there a process to evaluate the embodied carbon impact of the code as a whole.
- 5. **Transition to the Electrified Transportation Sector:** Similar to the embodied carbon framework, a framework is needed to account for the energy delivered to and used by EVs that are charged at buildings. This framework includes expanding the traditional boundaries of energy code compliance beyond the energy that is used at the site and must also incorporate the displacement of fossil fuel (gasoline, in this case) provided by the building.
- 6. **Energy Code Structure:** While this was not identified as a challenge, improving the energy code structure will clear the path towards building decarbonization.
 - a. Whether the cost-effectiveness test (TDV-driven) could be applied during code development only and not for code compliance should be evaluated.

- b. Expand the existing system performance approaches available in the compliance software. Currently, envelope only and mechanical only, trade-off approaches are available in the compliance software. These are used regularly by projects for code compliance. These system performance approaches must be more formally recognized in the energy code and expanded for more usability.
- c. Code complexity has been a known issue for at least one code cycle, brought upon by the steep increases in energy efficiency achieved in the past three or four code cycles. While it is tempting to continue down this path, the next quantum leap will only be achieved by improving the code structure that allows for system-wide and building-wide synergies to be achieved, resulting in a higher level of energy efficiency and performance. It is possible to leverage the existing CEC compliance software and apply system approaches that would raise the energy efficiency of all buildings.

Conclusions

California's 2022 energy code achieved deep reductions in energy consumption while also moving towards building decarbonization and the goals laid out in the 2021 IEPR. But 2030 is just around the corner and the list of statutes and goals that still need to be achieved is long. California needs to march towards its goals against the backdrop of a changing climate, varying energy prices, managing a declining gas infrastructure, evolving electric technologies, market transformation, and consumer behavior. The energy code must begin setting itself up to accommodate full decarbonization, transition to EVs, DERs, and grid harmonization. In this paper, we discussed these issues and provided focused recommendations for the 2025 and 2028 code cycles.

Progress for future energy code cycles to achieve decarbonization goals require an unprecedented rate of market transformation. This will the energy code to not only be able to address the real-time market conditions but, to some extent, be able to rely on forecasted data for cost-effectiveness.

Future Work

Some of the short- and long-term challenges identified earlier do not have immediate or clear solutions. More work needs to be done to develop solutions, demonstrate that they work, and fine tune them over time. This includes the following items:

- **Modeling of DERs:** There is not much uptake in utility DER programs, particularly in the nonresidential buildings sector. As more battery storage comes onto the grid and more data becomes available, the modeling of DERs is expected to improve. Improved modeling will result in better prediction of how and when storage is used, how it meshes with the electrification of the transportation sector, as well as the impact of building electrification on the grid peak.
- **Energy Accounting of the Electrified Transportation sector:** Work in the upcoming 2025 and 2028 code cycle must focus on developing an accounting methodology for EVs. This

is not an easy task and the solution will have to be iterated over the next few code cycle to ensure it has the desired affect on energy efficiency and DER requirements in the energy code.

- Embodied Energy Accounting: Similar to the accounting of EVs, embodied energy accounting must be incorporated into the energy code development process. Known solutions exist but more work needs to be done to fully incorporate them into the impact calculations.

References

- ASHRAE. 2019. "ANSI/ASHRAE/IES Standard 90.1-2019." *Energy Standard for Buildings Except Low-Rise Residential Buildings*. Atlanta, GA: ASHRAE.
- Athalye, Rahul, Randall Higa, and Will Vicent. 2020. "Performance Compliance in California: Where We Came From And Where We Need to Go." *ACEEE Summer Study on Buildings*. Asilomar, CA: ACEEE. 1-16.
- CEC. 2021. "2022 Building Energy Efficiency Standards for Residential and Nonresidential Buildings." *Title 24, Part 6, and Associated Administrative Regulations in Part 1*. Sacramento, CA: California Energy Commission. , August 19.
- CEC. 2021. "Building Energy Efficiency Standards Summary." *California Energy Commission*. August. https://www.energy.ca.gov/sites/default/files/2021-08/CEC_2022_EnergyCodeUpdateSummary_ADA.pdf.
- CEC. 2022. *Final 2021 Integrated Energy Policy Report, Volume I: Building Decarbonization*. Sacramento, CA: California Energy Commission.
- CEC. 2021. "Final Environmental Impact Report." *Amendments to the Building Energy Efficiency Standards (2022 Energy Code)*. Sacramento, CA, August 4.
- CEC. 2022. "Warren-Alquist State Energy Resources Conservation and Development Act." *Public Resources Code Section 25000 et seq.* Sacramento, CA: California Energy Commission, January.
- Delforge, Pierre. 2020. "Time for CA to Catch Up on Clean Energy in New Buildings." *NRDC*. November. <https://www.nrdc.org/experts/pierre-delforge/time-ca-catch-clean-energy-new-buildings>.
- Hedrick, Roger. 2020. "Impacts of 2022 Metrics on Nonresidential and High-Rise Residential Building Performance Compliance -- Updated with 20 Year Metrics." Sacramento, CA: California Energy Commission. , May 7.
- Hedrick, Roger, Eric Shadd, and Rahul Athalye. 2020. "Title 24 2022 ACM: Heat Pump Baseline Analysis -- Nonresidential Buildings." Sacramento, CA: California Energy Commission, October.
- ICC. 2021. "International Energy Conservation Code." Washington, D.C: International Code Council.
- Sontag, Michael, Brian Conlon, Snuller Price, Gabe Mantegna, Brian Horii, Oliver Garnett, Nichole Hanus, et al. 2020. *Time Dependent Valuation of Energy for Developing Building Efficiency Standards*. Sacramento, CA: California Energy Commission. <https://efiling.energy.ca.gov/GetDocument.aspx?tn=233257&DocumentContentId=65743>.