A Case Study on the Financial Implications of the Zero Net Energy (ZNE) Goal in California

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This paper is a case study that identifies potential financial implications from the updated Title 24, Part 6 code requirements established in 2019 by the California Energy Commission (CEC). The CEC works closely with the California Public Utilities Commission (CPUC), who's long term goal is to make all residential structures Zero Net Energy (ZNE) throughout the state. The CEC's updated code requirements include mandatory measures for detached residential homes to meet Zero Net Electricity on an Energy Design Rating (EDR) basis, a step towards Zero Net Energy. The purpose of this study is to understand the additional construction costs associated with the updated regulations, and how they may differ in various regions in California. The study was conducted on Lennar Corporation, the state's largest residential homebuilder, and sought out to identify the company's increased construction costs for homes permitted on or after January 1st, 2020. While the new regulations differ for homes of different shapes, sizes, and location, this study only pertains to detached, two-story, 2500 SF residential homes in climate zones three, seven, and thirteen.

Key Words: Residential, Zero Net Energy, Title 24, California Building Code, Financials

Introduction

History and Background

The State of California has long embraced visionary policies to aid with environmental protection and preservation. These achievements date back to 1974 when the state passed the Warren-Alquist State Energy Resources Act, creating the California Energy Commission (CEC) and becoming the first state in America to implement minimum energy efficiency standards. In 1978, the California Building Standards Commission (CBSC) enacted the California Building Standards Code; Title 24 of the California Code of Regulations. Within Title 24 are twelve different sub-parts, pertaining to different aspects of California's building code. In the same year, the CBSC created the Building Energy Efficiency Standards; Part 6 of Title 24. These standards were set in place to ensure builders in California are using the most energy efficient construction techniques and technologies. They apply to all new construction of, and additions and alterations to, residential and nonresidential buildings with the exception of correctional centers, jails, and prisons (California Energy Commission, 2019). The

CEC updates the Building Energy Efficiency Standards every three years by working with stakeholders in a public and transparent process. California builders anticipate these updates but are unaware of exact changes to code until they are released.

In 2008, the California Public Utilities Commission (CPUC) adopted the state's first Long Term Energy Efficiency Strategic Plan, serving as a roadmap to achieve maximum energy savings across all major groups and sectors in California. The unifying objective of this roadmap is a scaling-up of statewide energy efficiency efforts to meet urgent energy challenges. The plan set fourth ambitious goals for energy efficiency through 2020 and beyond, deemed "Big Bold Energy Efficiency Strategies" (California Public Utilities Commission, 2008, p. 6). The outlined strategies were:

1. All new residential construction in California will be zero net energy by 2020;
2. All new commercial construction in California will be zero net energy by 2030;
3. Heating, Ventilation, and Air Conditioning (HVAC) will be transformed to ensure that its energy performance is optimal for California's climate; and
4. All eligible low-income customers will be given the opportunity to participate in the low-income energy efficiency program by 2020.

While this *Strategic Plan* is not a governed code within Title 24, the California Building Standards Commission has been slowly implementing new requirements in their updated Building Energy Efficiency Standards to help reach these goals. This study will focus strictly on the new means and methods of residential construction being put in place in California to reach this goal.

CEC 2019 Residential Energy Efficiency Standards

The 2019 Building Energy Efficiency Standards is the most recent update to Part 6 of Title 24, improving upon the 2016 Energy Standards. Buildings permitted on or after January 1, 2020 must comply with the new set of standards. The update contains significant code changes to residential construction, and some industry professionals have said it is the biggest change they have ever seen.

Before digging into this update, it is important to understand the three different types of code requirements under Title 24: mandatory, prescriptive, and performance. Mandatory measures require every building to meet the requirement. Provided that the mandatory requirements are met, project teams can follow either prescriptive or performance codes. Prescriptive codes pertain to individual components of a building, while performance codes require a whole buildings design to meet a certain standard. The performance approach is often used for new construction, while the prescriptive approach is common for tenant improvement or renovation projects (California Energy Commission, 2019, p. 5).

In this update, mandatory measures include, but are not limited to: high performance walls, high performance attics, continuous insulation, high efficiency SEER, EER, DHW, cool roofs, insulated doors, high efficiency windows, HERS testing, radiant barriers, and photovoltaic systems, or solar (unless exceptions are met). For this study, it is assumed that no solar exceptions are met.

Prescriptive measures can be installed by the builder's discretion, as long as the performance measures are met. Performance requirements are gauged using the Energy Design Rating (EDR) Index. This is a scale from zero to one hundred, where zero represents a building that has zero net energy consumption and one hundred represents a building that is minimally compliant with the 2006 energy code (the lower the better). Ratings consist of three elements: energy efficiency, solar/storage,

and final score. Final score is calculated by subtracting EDR values gained from solar/storage by EDR values gained through energy efficiency (see Figure 1).

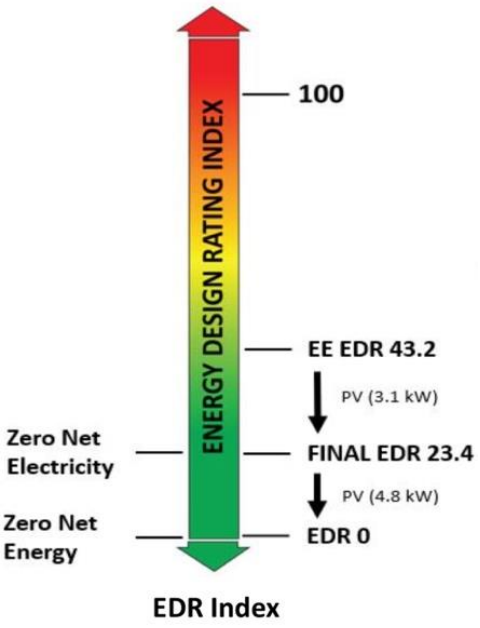

Figure 1. Energy Design Rating (EDR) Index Example (Lieu, 2019)

In Figure 1, the energy efficiency required EDR value is 43.2, which can be achieved through prescriptive measures outlined in Title 24, Part 6. These prescriptive measures are incremental points gained through the installation of various home features, measured by the CEC's approved software for energy modeling. Figure 1 also shows a final EDR value of 23.4, which was (for this example) the minimum value required to attain Zero Net Electricity. The final EDR was achieved through the installation of a 3.1 kW photovoltaic system.

Overall, the California Energy Commission's (CEC) 2019 Residential Energy Efficiency Standards does not require homes to be Zero Net Energy, rather, they must be Zero Net Electricity using the Energy Design Rating (EDR) Index. The EDR value required to meet Zero Net Electricity is different for each type of residential structure, its size (SF) and the climate zone in which it is constructed.

California Building Climate Zones

The California Energy Commission established 16 climate zones that represent a geographic area for which an energy budget is established. An energy budget is the maximum amount of energy that a building, or portion of a building, can be designed to consume per year. The climate zones are based on energy use, temperature, weather and other factors (California Energy Commission, 2018). The new Energy Standards contain climate zone-dependent prescriptive measures, meaning the measures change based on climate zone. Design data and requirements for each climate zone include the warmest and coolest outdoor temperatures that a building is likely to experience in an average year in a particular location. For example, zones that are expected to experience high temperatures will

require increased insulation due to necessary HVAC systems. A map of California's Building Climate Zones is shown in Figure 2, provided by the California Energy Commission.

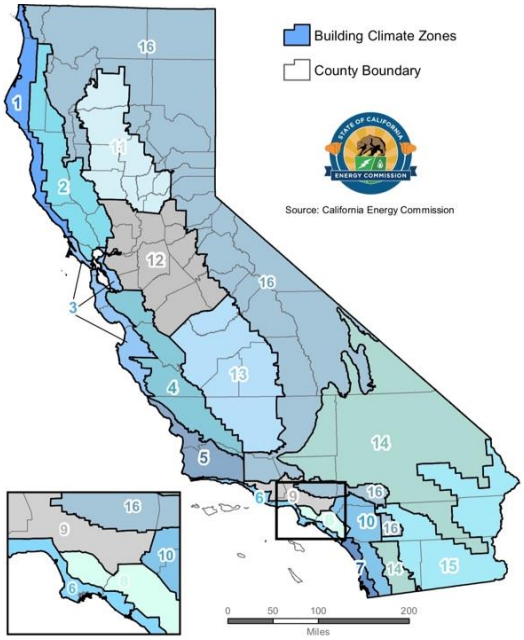

Figure 2. Building Climate Zones, California (California Energy Commission, 2018)

Literature Review

When drafting the updates, the CEC was required to show an overall cost savings for homeowners over the course of a 30-year mortgage. Energy and Environmental Economics (E3), an outside consulting firm, provided an analysis of Title 24 for the CEC. The report was mostly an analysis of mandatory solar PV requirements, with cost impacts and long-term savings. The analysis concluded that the new 2019 Title 24 requirements will increase the cost of constructing a new home by an average of $9,365 per household using an average system size and current incremental construction costs (Energy and Environmental Economics, 2018). It must be noted that this cost increase was solely due to the mandatory installation of PV systems, and no other construction costs.

Methodology

Objective

The objective of this case study is to identify and predict increased construction costs associated with the updated 2019 California Residential Energy Efficiency Standards and to understand how these costs may differ throughout the state. The study was conducted on the Lennar Corporation, California's largest residential homebuilder, and the nation's second largest residential homebuilder by revenue (Construction Dive, 2019). Both qualitative and quantitative data was collected in this

study to identify different construction methods by climate zone, and costs associated with those methods. Data was collected through phone and email interviews with Lennar associates, along with data forwarded from Lennar's energy consultants. Lennar provided numbers on a cost per square foot basis, prescriptive/performance packages associated with different climate zones, and estimating techniques utilized to reach accurate predictions.

Target Group

This case study focuses on all newly constructed two-story detached residential homes of 2,500 square feet in climate zones three, seven, and thirteen in California. The representative city for each of these climate zones (CZ) are as follows (as seen in Figure 2, Building Climate Zones map):

CZ-3	CZ-7	CZ-13
Oakland	San Diego-Lindbergh	Fresno

These climate zones were chosen due to their differing annual temperature fluctuations, with the goal of identifying drastic cost differences based on climate. The costs identified in this report are strictly additional direct construction costs (labor, material, equipment) pertaining to the different zones. To clarify, the quantitative and qualitative data included in this report are only those that have been added onto Lennar's 2016 Residential Energy Efficiency Standards building packages, to comply with 2019.

Hypothesis

It is expected that direct construction costs on two-story, detached residential homes of 2,500 square feet are going to increase throughout the state of California. The intent of this study, though, is to determine *how much* that increase will be in U.S. Dollars. The new Energy Standards take effect upon homes permitted on or after January 1st, 2020, so builders are trying to predict how these new plans will influence construction costs. In this study, estimates are performed on three climate zones, and it is expected that CZ-13 will have the highest cost increase, due to its extreme annual temperatures.

Analysis

Mandatory Measures

With either prescriptive or performance compliance, there are mandatory measures that must always be met. Some deal with infiltration control and lighting, while others require minimum insulation levels or equipment efficiencies. Mandatory measures for all two-story, detached residential homes of 2,500 square feet are as follows (per Lennar Corporation):

- Lighting
    - Screwless recessed downlight luminaires (JA8)
    - Less than 5 Watt night-lights, step-lights, and path-lights
- Heating, Ventilation, and Air Conditioning (HVAC)
    - Minimum Efficiency Reporting Value (MERV) 13 air filter
- Electric Heat Pumps
    - Split air-source electric heat pumps (HSPF graded)

    - Variable Refrigerant Flow (VRF) systems
- Water Heating
    - All pipes insulated
    - Mandatory minimum 0.80 UEF for gas, and 0.91 UEF for electric
- Ventilation
    - Air filtration on supply and balanced mechanical systems
    - Testing for HERS rating on kitchen hoods
- Solar
    - Photovoltaic system based on projected annual electrical usage

These measures stay consistent throughout all three climate zones in this study, meaning all increased construction costs from mandatory measures will be equal. It is assumed that all photovoltaic (solar) features for homes in this target group have a 3.0 kW (3000W) system.

Prescriptive Measures

As stated previously in this paper, homebuilders are able to reach "performance" energy compliance in a number of ways, based on "prescriptive" measures and their scores on the Energy Design Rating (EDR) Index. The sum of EDR points attributed to each prescriptive measure must meet a designated value, or e*fficiency requirement*, based on climate zone.

Table 1 shows efficiency requirement values (gained from prescriptive measures) from the old and new code, as well as the target improvement necessary from the most recent Efficiency Standards.

Table 1

Prescriptive Requirement Comparisons, by EDR Rating (2,500SF Two-Story Detached)

	Climate Zone 3	Climate Zone 7	Climate Zone 13
2016 Efficiency Requirement	42.9	50.3	32.3
2019 Efficiency Requirement	49.1	51.4	46.8
Target Improvement	6.2	1.1	14.5

In this study, prescriptive cost estimates of two scenarios in each climate zone were performed; 2x4 and 2x6 building envelope framing. This was done to show how homebuilders can achieve prescriptive code compliance through different methods of prescriptive feature inclusion. Tables 2-4 show prescriptive measures chosen in this study for each climate zone, and the two different scenarios of achieving the Efficiency Requirement based on EDR points gained from each feature.

Table 2

Climate Zone 3: Prescriptive Measures Chosen, by Scenario

Feature:	EDR Gained	Scenario 1 (2x4)	Scenario 2 (2x6)
1 Coat Stucco + R4 Continuous Insulation	2.8	x	x
2x4 Exterior Walls (R-15 Insulation)	0.6	x	
2x6 Exterior Walls (R-20 Insulation)	2.7		x
95 EF Domestic Hot Water	0.9	x	
92 EF Domestic Hot Water	0.7		x

95 AFUE Furnace	2.5	x	
92 AFUE Furnace	2.1		x
R-49 Attic Insulation	0.2	x	
Total EDR Gained (6.2 Required):		7.0	8.3

Table 3

Climate Zone 7: Prescriptive Measures Chosen, by Scenario

Feature:	EDR Gained	Scenario 1 (2x4)	Scenario 2 (2x6)
1 Coat Stucco + R4 Continuous Insulation	1.5		x
2x4 Exterior Walls (R-15 Insulation)	0.2	x	
2x6 Exterior Walls (R-20 Insulation)	1.5		x
92 EF Domestic Hot Water	0.7	x	
92 AFUE	0.5	x	
Total EDR Gained (1.1 Required):		1.4	3.0

Table 4

Climate Zone 13: Prescriptive Measures Chosen, by Scenario

Feature:	EDR Gained	Scenario 1 (2x4)	Scenario 2 (2x6)
1 Coat + R4 Continuous Insulation	3.6	x	x
2x4 Exterior Walls (R-15 Insulation)	0.8	x	
2x6 Exterior Walls (R-20 Insulation)	3.8		x
95 EF Domestic Hot Water	0.5	x	
92 EF Domestic Hot Water	0.4		x
95 AFUE Furnace	1.6	x	
92 AFUE Furnace	1.3		x
Triple Pane Windows (U-Value 0.23/0.22)	0.6	x	
R-8 Duct Insulation	0.5	x	
AC Rating (16 SEER / 13 EER)	2.6	x	x
AC Refrigerant Charge (HERS Inspection)	1.7	x	x
HPA-B R38+15 High Performance Attic	4.8	x	x
Total EDR Gained (14.5 Required):		16.7	18.2

As seen in Tables 2-4, both scenarios achieve the required EDR improvement from 2016's code in each climate zone, based on the features chosen. They were chosen by Lennar Corporation, and what they consider "sellable code features," based on constructability, cost, and customer appreciation.

Findings

After determining what prescriptive measures were to be included in each home in the target group, a construction cost estimate was performed to determine total price of these features. Estimates were based on a cost-per-square-foot basis, originating from prescriptive costs on a 2,365 square foot

average home in California. The costs include labor, material, and equipment. See Table 5 for total additional construction costs by climate zone and scenario, with average calculations.

Table 5

Direct Construction Costs of Prescriptive Measures Chosen (Tables 2-4)

	Climate Zone 3	Climate Zone 7	Climate Zone 13
Scenario 1 (2x4)	$3,282	$1,050	$7,695
Scenario 2 (2x6)	$2,794	$1,744	$6,610
Average	$3,038	$1,397	$7,152

As seen in Table 5, average additional direct construction costs range from $1,300 to $7,200 in climate zones 3, 7 and 13. Once prescriptive measure costs were determined, mandatory measure costs were added to each climate zone to determine total additional direct construction costs.

Table 6

Total Direct Construction Costs

	Climate Zone 3	Climate Zone 7	Climate Zone 13
Mandatory Measures	$25,592	$25,592	$25,592
Prescriptive Measures	$3,038	$1,397	$7,152
Total Cost Increase	$28,630	$26,989	$32,744

As seen in Table 6, it was determined that total additional direct construction costs on climate zones 3, 7 and 13 ranged from $26,000 to $33,000 after finding the sum of mandatory and prescriptive costs.

Considerations

There are many considerations to be taken in the estimates calculated in this study, such as additional design components that will alter the conclusions reached here. For example, building orientation can greatly affect the energy use of a building, particularly in cooling-dominated climate zones with a high amount of west-facing glass. Homes may also have different “glazing percentages,” affecting the amount of natural light and heat entering the conditioned floor area.

Photovoltaics (PV) play a huge role in the mandatory measure costs seen in Table 6, accounting for $13,800 of the $25,592 shown. Per 2019 code, some homes may qualify for a PV exception such as limited unshaded roof space, homes with large battery storage systems, and the climate zone in which the home is built (California Energy Commission, 2019). Some residential builders (or owners) can apply for government loan programs, utility incentives, and rebate programs to reduce the cost of PV systems.. In this study, an 8% government rebate was applied to the cost of the 3.0 kW PV systems.

Conclusion

The 2019 code update is a major step towards meeting the Zero Net Energy (ZNE) goal set fourth by the California Public Utilities Commission and is the most recent of three updates to move California

toward achieving that goal. Homebuilders are scrambling to prepare for the implementation of 2019's update and those that have yet to come. Direct construction cost increases from 2016 to 2019's code were found to be the highest in climate zone 13, followed by climate zone 3 and lastly climate zone 7. This is likely due to fluctuations in climate within those zones, and how the California Energy Commissions approved software for energy modeling calculates EDR values for the zones.

As seen in Table 6, total direct construction cost increases were found to be $32,744 in CZ-13, $28,630 in CZ-3, and $26,989 in CZ-7. After some simple calculations of price per square foot, these numbers equate to $13.10/SF, $11.45/SF, and $10.80/SF respectively. To put this into perspective, Lennar Corporation stated that their average construction cost of homes built in this target group are $96.00 per square foot. The average increase within the target group was $11.78, which is a 12.3% increase in construction cost per square foot for Lennar Corporation, a significant increase.

This case study is a representation of current industry predictions based on Lennar Corporation's estimated costs and aims to serve as a "snapshot" of projections at a given moment in time. Further research needs to be done on actual direct construction costs once homes permitted in 2020 are constructed, and how future code changes can impact the residential construction industry.

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