RIGHT TYPE RIGHT PLACE

Assessing the Environmental and Economic Impacts of Infill Residential Development through 2030

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EXECUTIVE SUMMARY

California's long-term economic prosperity and environmental sustainability will depend on how much and where housing gets built in the state.

Residents in the largest coastal cities in California encounter some of the most unaffordable homes in the nation, caused in large part by a thriving economy and a multi-decade-long undersupply of housing relative to population and job growth. In addition to the income squeeze of unaffordable homes and long commutes, the housing shortage creates environmental challenges. Most prominently, building more auto-dependent housing far from job centers generates more traffic and air pollution while destroying open space and agricultural lands. Furthermore, these development patterns undermine that state's long-term greenhouse gas reduction goals, including newly legislated 2030 targets.

California instead could meet long-term economic and environmental objectives by building the right type of housing in the right places. That means homes that allow for reduced driving, as well as less energy and water usage, with compact development near transit, goods, and services.

Other than one industry-based analysis, California has lacked an objective and comprehensive assessment of the potential economic and environmental impacts of new housing production on the state's 2030 climate goals. To address this research gap, the Center for Law, Energy, and the Environment (CLEE) at UC Berkeley School of Law and the Terner Center for Housing Innovation at UC Berkeley (collectively the "Centers"), with support from Next 10, prepared this report to assess the environmental and economic impacts of housing production scenarios that could help meet the state's proposed 2030 greenhouse gas reduction target under Senate Bill 32 (Pavley, 2016). This report also offers best practices and policy recommendations for state and local governments to boost housing production within California's existing urban footprint. The Centers have assessed existing data and consulted with development experts to quantify the costs and benefits of a 2030 growth scenario that can inform state and local policy going forward.

Of the three housing production scenarios analyzed, the Centers found that the infill-focused housing growth scenario provides the best outcomes for meeting the state's climate goals while also producing economic benefits. This scenario could help avert at least 1.79 million metric tons of greenhouse gases annually compared to the business-as-usual scenario, based on reduced driving miles and household energy usage alone. That number is equivalent to:

- Averting emissions from 378,108 passenger vehicles and from burning over 201 million gallons of gasoline annually[1]
- Almost 2/3 of the total statewide emissions decrease California achieved between 2013 and 2014 alone
- Almost 15 percent of the emissions reductions needed to reach the state's Senate Bill 375 (Steinberg, 2008) targets from statewide land use changes

Together with other land use changes that this housing scenario could stimulate, the savings would help the state meet its goals of reducing emissions from a projected 431 million metric tons in 2020 to 260 million metric tons by 2030, as required by state law.[2]

The infill scenario produces slightly higher annual economic growth, more tax revenue, and lower overall construction costs than business-as-usual growth. Meanwhile, the average household would see lower overall monthly costs through reduced transportation and utility bills from living in infill neighborhoods. Furthermore, infill households would drive roughly 18 miles less per weekday than non-infill households.

Three Housing Growth Scenarios through 2030

This report presents three housing development scenarios for the state through 2030: (i) a business-as-usual "baseline," (ii) a "medium" infill scenario, and (iii) an infill "target" scenario. All three scenarios assume that the state will build enough housing to meet projected population increases through 2030 as forecast by the state's Department of Finance. They vary only in the location and housing types that would be built.

Location: the Centers define location primarily as "infill" and "non-infill," with infill generally described as compact housing (single family or multifamly, but on small lots) on urbanized land near transit, in communities where residents do not have to drive long distances. This type of development is more environmentally beneficial than building in non-infill areas, where driving miles and energy usage are typically much higher. This study defines infill based on areas that either (i) have lower-than-average household vehicle miles traveled (VMT) or (ii) are in more car-dependent areas but within three miles of significant rail stations. These rail-adjacent areas thus have the potential to become low-VMT neighborhoods in the next 15 years.

The report further analyzes location based on coastal or inland counties and Northern versus Southern California, given that the economics of home construction and land values vary greatly among these categories.

The three scenarios project the location of all new housing development through 2030 as follows:

Scenario	Units Produced 2015-2030	Description
Baseline	1,924,832	Development follows the same patterns as 2000-2015
Medium	1,924,832	Much more development occurs in infill areas than has historically ocurred
Target	1,924,832	All new development occurs in infill areas of California

Source: N/A (number comes from CA Dept of Finance household projections, adjusted upward to hold vacancy rate constant)

Housing Type: this study examines varied mixes of four different housing types across the three scenarios:

- Single-family detached
- Single-family attached & 2-4 unit buildings
- Multifamily low/midrise
- Multifamily high-rise

Generally, the Baseline Scenario has more single-family detached housing as a percentage of the overall mix, while the Medium and Target Scenarios have more multifamily.

Key Findings

Modeling the effect of these three housing scenarios on key environmental and economic indicators produces the following results:

- The Target Scenario offers at least 1.79 million metric tons of greenhouse gas reduction annually compared to the Baseline (business-as-usual) Scenario, based on reduced driving miles and household energy usage. These savings will likely be even greater when accounting for new commercial development that could occur in infill areas, as well as the potential emissions savings from not building on open space and agricultural land that currently sequesters carbon.
- The economic impacts across all three scenarios are remarkably consistent, meaning that these environmental gains can occur with virtually no negative economic impacts and potentially significant economic gains.

- The Target Scenario outperforms the Baseline and Medium Scenarios with higher annual economic growth (greater than $800 million more per year from the Baseline scenario), more tax revenue (greater than $5.4 million more per year), and lower overall construction costs (a savings of more than $13 billion over 15 years).
- The Target Scenario has lower construction costs than in the Medium and Baseline Scenarios. Although slightly fewer construction jobs are needed due to this lower cost (due largely to infill units being smaller than non-infill units overall), the Target Scenario offers higher-wage construction jobs than the Baseline Scenario, resulting in approximately $542 million more in annual residential construction job income.
- While more housing growth in the job-rich coastal cities could lead to slightly higher average home prices and rents (due to higher construction costs and land values in these locations), the average household would see lower overall monthly costs in the Target and Medium Scenarios compared to the Baseline Scenarios. Any increase in home prices and rents in these areas are offset by lower transportation and utility costs from building in infill areas. Under the Target scenario, renters still save $26/month and homeowners save $13/month.

The following chart summarizes these results in greater detail.

Distribution of Development Type

Scenarios	Business as Usual (BAU)				Medium				Target			
	Infill Coastal	Infill Inland	Non-infill Coastal	Non-Infill Inland	Infill Coastal	Infill Inland	Non-infill Coastal	Non-Infill Inland	Infill Coastal	Infill Inland	Non-infill Coastal	Non-Infill Inland
Single-family detached	10%	13%	12%	27%	16%	20%	6%	13%	21%	27%	0%	0%
Single-family attached & 2-4 unit	4%	1%	2%	2%	6%	2%	1%	1%	8%	2%	0%	0%
Multifamily low/midrise	16%	3%	5%	3%	24%	4%	3%	2%	33%	6%	0%	0%
Multifamily high-rise	1%	0%	0%	0%	2%	0%	0%	0%	3%	0%	0%	0%

RESULTS

Scenarios	Business as Usual	Medium	Target	Target savings over BAU
Carbon Reductions from VMT (MM tons GHGe [greenhouse gas equivalent] annually)	0%	.89	1.79	–
Average Annual Income Per New Construction Job	$51,000	$51,791	$52,590	–
Total 15-Year Construction Costs	$680,441,981,775	$673,947,524,792	$667,453,067,809	$12,988,913,966
Annual Residential Construction Job Income	494,561	492,240	489,920	542,281,800
Annual Economic Growth	$79,014,111,473	$79,418,304,288	$79,822,497,101	$808,385,628
Increased Annual Tax Revenue	$3,812,307,665	$3,815,009,189	$3,817,710,649	$5,402,984
Monthly Household Utilities	$149	$146	$144	($5)
Monthly Transportation Costs	$1,109	$1,080	$1,051	($58)
Average Monthly Rent	$2,666	$2,684	$2,702	$36
Average Home Price	$367,527	$374,439	$381,350	$13,823
Average Monthly Mortgage Payment*	$1,431	$1,458	$1,485	$54
Total monthly renter expenses (utilities + transportation + rent)	$3,924	$3,911	$3,898	($26)
Total monthly owner expenses† (utilities + transportation + mortgage)	$2,573	$2,567	$2,560	($13)

* Assuming an 80% LTV, 30 year FRM at Freddie Mac January 2017 rate of 4.16%
† Not including property taxes or property insurance

Policy Recommendations

Achieving the Target Scenario or moving toward the Medium Scenario will not occur without significant policy action. Local leaders in prime infill areas should consider:

- Changing zoning to allow for more multifamily use, reduced parking requirements, and increased allowable density, while shortening overly lengthy permitting timelines;
- Implementing anti-displacement policies, such as preservation of affordable housing, tenant protection, and guarantee of lease renewal;
- Directing more funds to rail and bus rapid transit investments in infill areas and improving bus and other connections to rail and bus rapid transit, including through enhanced biking and pedestrian infrastructure; and
- Developing urban growth boundaries to protect critical open space and farmland from further development and environmental degradation, provided incentives are in place for more infill development and housing affordability.

State leaders should consider:

- Encouraging local action to permit more responsible infill development, such as through:
    - » Developing a state program modeled on Massachusetts' Chapter 40B in which local regulatory barriers to development can be overridden for housing production in municipalities that do not meet regional affordability targets;
    - » Allocating more property tax revenue to municipalities that generate housing in low VMT neighborhood types;
    - » Establishing a regional tax-sharing system with benefits to municipalities that meet regional housing goals;
    - » Creating demand-side programs for infill housing, such as rebates or down-payment assistance for homes in low-VMT neighborhood types
    - » Reducing local parking requirements in infill areas;
    - » Supporting urban growth boundaries to protect critical open space and farmland from further development and environmental degradation, provided incentives for infill development and housing affordability are simultaneously in place;

- Increasing funding for affordable housing, such as through bolstered Affordable Housing and Sustainable Communities (AHSC) funding from cap-and-trade auction proceeds and infrastructure financing programs;
- Improving transportation and transit investments in prime infill areas by:
    - » Developing transportation pricing strategies to facilitate reductions in VMT, while ensuring that low income families do not face an undue cost burden;
    - » Directing more funds to rail and bus rapid transit investments and operations in infill areas, such as the Transit and Intercity Rail Capital Program;
    - » Improving bus and other connections to rail and bus rapid transit, including through enhanced biking and pedestrian infrastructure;
    - » Developing project performance standards for all state infrastructure facilities to prioritize proposed projects based on their estimated performance reducing overall vehicle miles traveled and greenhouse gas emissions; and
- Ensuring that the California Environmental Quality Act (CEQA) provides more certainty and streamlined processing for infill projects that meet state environmental goals.

Further research should explore the financial feasibility of these scenarios, employ parcel-level analysis to help refine the conclusions offered, and expand the study to look at commercial development, as well as redevelopment opportunities. Future research could also model the effects of the policies recommended in order to identify those that would be most effective. Ultimately, California policy makers at the state and local levels will need to demonstrate a willingness to tackle housing challenges, in order to guarantee continued economic prosperity and environmental stewardship in the state.

INTRODUCTION

Lack of infill housing development hurts the economy and the environment.

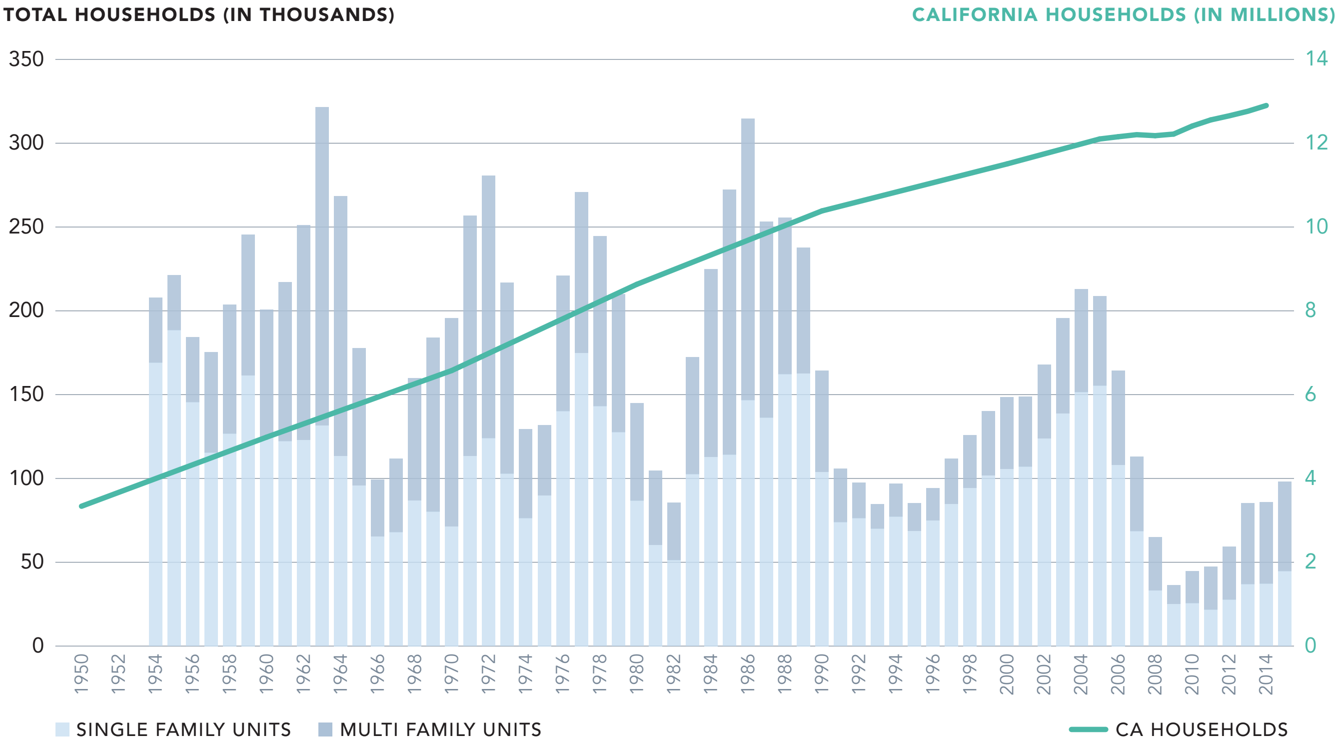
Californians encounter some of the most unaffordable housing markets in the country. One of the primary culprits is an undersupply of infill housing (generally described as compact housing on urbanized land close to transit, jobs, and services) in major metropolitan areas near the coast. The problem has become more severe since the 1970s. Experts identify local land use restrictions as one of the primary causes.[3] Despite high market demand,[4] the state's largest coastal metropolitan areas have largely failed to provide sufficient housing supply to match population and job growth, particularly in transit-rich neighborhoods in the core.[5] As a September 2016 study from the White House Council of Economic Advisors found nationwide, local land use policies make developable land more costly through zoning restrictions, off-street parking requirements, preservation regulations, and unnecessarily slow permitting processes, among other factors.[6] High land and building costs also contribute to overall higher housing costs in California compared to many other parts of the country.[7] Meanwhile, the lack of local financing tools, such as redevelopment funding, has also exacerbated local governments' ability to plan for and provide housing that is affordable in California's urban areas.[8]

Figure 1 below shows the steady growth of the state's population plotted with the cyclical rise and fall of housing production. While the large trends in the state's housing production are largely the result of national-scale changes (such as the decline in multifamily production after the 1986 tax reform and the recent housing boom and bust), the under-production of housing relative to population growth can clearly be seen in the past few decades.

The failure to build is not due to lack of demand: even in the San Joaquin Valley, a Council for Infill Builders study based on consumer preference data and economic trends suggested that the majority of future demand for new homes will be for apartments, townhomes and small-lot, single family homes in walkable neighborhoods.[9]

The undersupply of infill housing has created significant environmental challenges in the state. Restrictive local policies have pushed new housing development toward the metropolitan fringe, resulting in more air pollution caused by increased driving miles from longer commutes, lost open space and farmland, and greater water and energy consumption from large-lot, exurban homes. By contrast, more infill housing means lower green-

Figure 1: Historic Patterns of Growth in CA Population and Housing



Source: Construction Industry Research Board; US Census Bureau

house gas emissions due to fewer vehicle miles traveled, preservation of open space for agriculture and other beneficial uses, and less consumption of water and energy.[10]

Given the economic and environmental needs, California has made efforts at the state and local levels to encourage more infill housing. As an example, SB 375 (Steinberg, 2008) requires regional transportation plans to direct more transportation dollars to infill areas in order to meet state greenhouse gas targets, which the California Air Resources Board sets for each region based on existing land use plans and possible incremental improvements in land use patterns.

State policy makers have also streamlined environmental review for infill housing under the California Environmental Quality Act (CEQA), through SB 375 for development projects consistent with regional transportation plans,[11] SB 226 (Simitian, 2011) for infill projects in low vehicle miles traveled areas,[12] and SB 743 (Steinberg, 2013) for projects in infill areas that reduce vehicle miles traveled. In addition, the legislature has allocated certain funds generated by California's cap-and-trade auction program to promote sustainable development, which includes infill projects.[13] At the local level, communities such as Oakland and Sacramento have adopted reforms that ease parking requirements on infill projects.[14]

Yet as California continues its ambitious effort to reduce the greenhouse gas emissions that cause climate change, the progress on new housing to date is unlikely to be sufficient to achieve these goals. Specifically, California seeks to reduce greenhouse gas emissions to 1990 levels by 2020 per AB 32 (Nuñez, 2006), representing a 15 percent reduction over business-as-usual. The state has additional goals for 2030, seeking reductions of 40 percent below 1990 levels per SB 32 (Pavley, 2016). Governor Brown's 2015 Executive Order B-30-15 also set a target of 80 percent below 1990 levels by 2050.

Given that almost 40 percent of greenhouse gas emissions in the state come from the transportation sector (including high vehicle miles traveled as residents drive long distances to work, shop and access services), locating walkable or bikeable housing near transit and other amenities will be critical to meeting long-term reduction targets, even with improvements in low-carbon fuels. As a result, the AB 32 Scoping Plan for the transportation sector states, "plan and build communities to reduce vehicular [greenhouse gas] emissions and provide more transportation options," as one of four strategies to be employed.[15] Furthermore, compact infill housing often involves less water and energy usage due to the smaller lot size and square footage. New housing construction can therefore help the state meet these long-term greenhouse gas goals, if the state and local governments allow more of the right housing types in the right places.

In this report, the Center for Law, Energy and the Environment (CLEE) at the UC Berkeley School of Law and the UC Berkeley Terner Center for Housing Innovation (collectively the "Centers"), with support from Next 10, examine how infill residential development could help the state reach its 2030 emissions targets in SB 32.

Assessing the Impact of California's Climate Goals on New Housing Construction

This report represents the first academic analysis of how residential development could help achieve the 2030 goals. In 2015, the California Building Industry Association (CBIA) (through the California Homebuilding Foundation) released a study that purported to show that the 2030 and 2050 greenhouse gas reduction targets in then-proposed SB 32 would increase construction costs and home prices, resulting in significant economic and job losses in the residential housing sector.[16] Yet that study incorrectly relied on an assumption that the 2030 goals would create a de facto and immediate mandate that all new residential construction in the state have a minimum standard of "zero net energy," despite ongoing state plans to achieve this result anyway, in a measured fashion. It also assumed without explanation, and in contradiction to current regulatory proposals, that compliance with such a standard would necessarily require builders to include rooftop solar panels with all new homes, at estimated prices that were inflated and untethered to current price trends. Finally, the study assumed without evidence that all residential projects would have to comply with the statewide greenhouse gas standards through state-mandated environmental review, also unsupported by recent case law.[17] In short, the study assumed unrealistic mandates and exaggerated the likely costs.

Other than the industry-based analysis, California lacks an objective and comprehensive assessment of the potential economic and environmental impacts of new housing production on the state's 2030 climate goals. To address the research gap, the Centers prepared this report to assess the environmental and economic impacts of housing production scenarios that would help meet the state's proposed 2030 greenhouse gas reduction target. This report also offers best practices and policy recommendations for state and local governments to boost housing production within California's existing urban footprint. The Centers have assessed existing data and consulted with development experts to quantify the costs and benefits of a 2030 growth scenario that can inform state and local policy going forward.

The Centers have identified business-as-usual "Baseline," "Medium," and "Target" housing scenarios that could help the state meet the 2030 greenhouse gas goals. The Centers have also reviewed current literature and assessed existing data to determine the key economic and environmental indicators at issue with new housing construction and have identified research gaps. Based on that assessment, the Centers have estimated the likely impacts of the scenarios on select economic and environmental indicators, including the following:

- Jobs (direct and indirect)
- Income
- Economic growth
- Construction costs
- Household utility and transportation costs
- Housing prices/rents
- Carbon emissions/vehicle miles traveled (VMT)

Where data were missing, the Centers undertook new research, including IMPLAN modeling, where feasible to fill gaps.

Based on the data collected and analyzed, the Centers have made quantitative projections for each indicator, providing the public and policy-makers with a range of "bottom-line" environmental and economic impacts that flow from the scenarios. The estimates that result from this analysis should provide a framework for understanding the likely extent and direction of differences between scenarios. More extensive research would be necessary to develop more detailed estimates of impacts.

Based on this analysis, the Centers offer policy recommendations, as well as suggestions for further research.

ANALYTICAL APPROACH

Definition of Infill

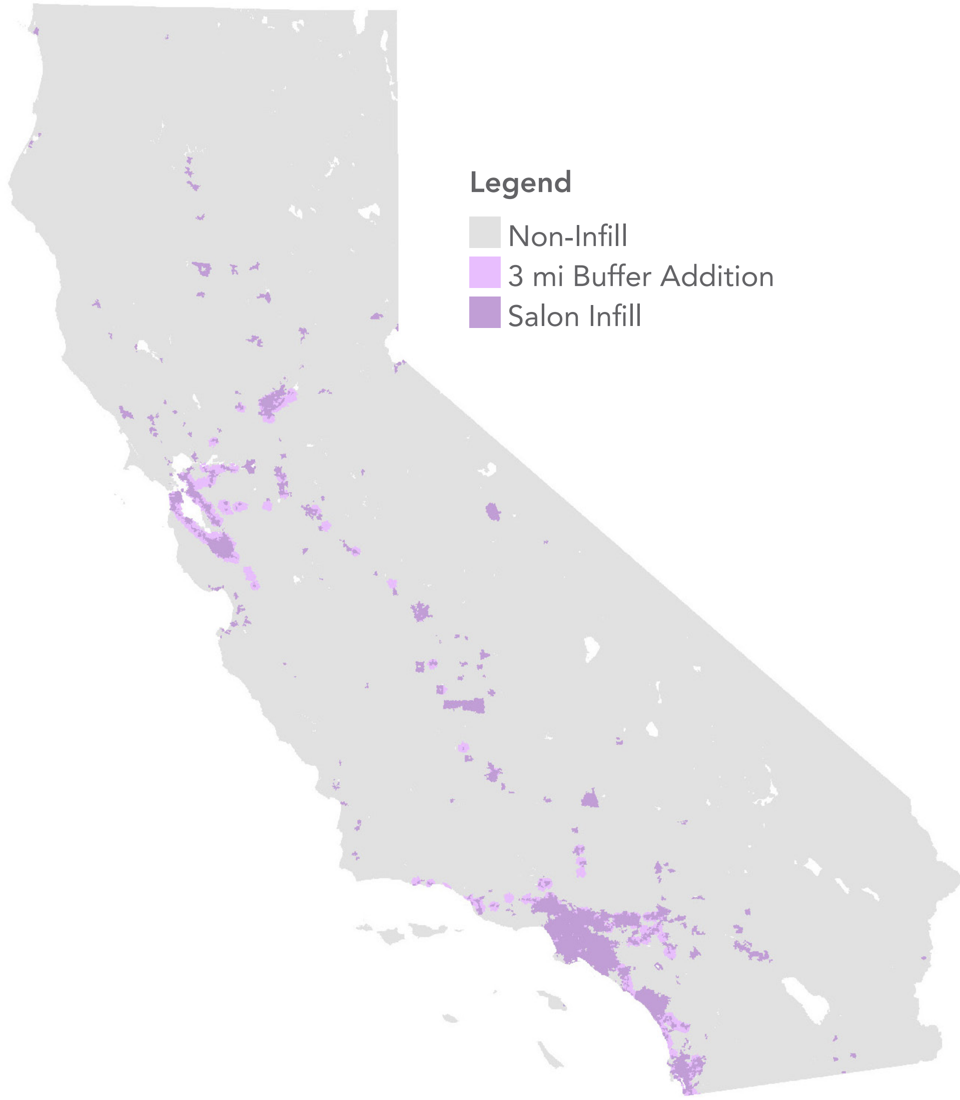
This study uses a definition of infill that identifies areas that either (i) have lower-than-average household vehicle-miles-traveled (VMT) or (ii) are in more car-dependent areas but within three miles of significant rail stations and thus have the potential to become low-VMT neighborhoods in the next 15 years. While there are numerous definitions of "infill," this study focuses squarely on the impact of neighborhood type on driving behavior. As a result, we base our definition on the most current and comprehensive analysis (to our knowledge) of the association between neighborhood type and driving in California, a California Air Resources Board-funded study conducted by Deborah Salon et al (referred to here as the "Salon et al. study"). It calculated VMT across neighborhoods in California, providing a way to estimate VMT in infill versus non-infill areas (see the methodology section for more details).

"Infill" is a flexible term, and while scholars and policymakers generally agree that it includes already-developed areas, they have offered many different specific definitions. While some have limited the definition to walkable neighborhoods or areas that have access to transit, others have focused on multifamily housing, as opposed to single-family detached homes. These definitions are often based on differing policy goals, such as ensuring clarity for developers in the entitlements process or ensuring efficient use of existing infrastructure. Because this report focuses on the potential for infill development to reduce household VMT, the Centers use a definition of infill from the Salon study, along with areas close to rail stations. While this definition allows for estimates of VMT reductions under different development scenarios, it does not necessarily provide insight into other aspects of the scenarios, such as financial feasibility. A parcel-level analysis could provide this level of insight but is beyond the scope of this report.

The definition of infill in this study is both expansive and restrictive, identifying infill areas in over 80% of the state's counties but encompassing only 4% of the state's total land area. The infill definition provides households with ample choice about where to live, given that infill areas are in nearly every part of the state and that investments in rail infrastructure could expand these areas even further.

Figure 2 below shows the low-VMT tracts identified by Salon et al., plus the three-mile buffers around the train stations. Broadly, the state's major metro areas, including Sacramento, San Diego, the San Francisco Bay Area, and the Los Angeles metropolitan area, noticeably contain most of the infill areas. Numerous other smaller infill areas, most of which are the downtowns of small cities, dot the state. A few of the low-VMT areas identified by Salon that are neither in the large metro areas nor in the smaller downtowns across the state are relatively unpopulated tracts that are nevertheless within census-designated urbanized areas.

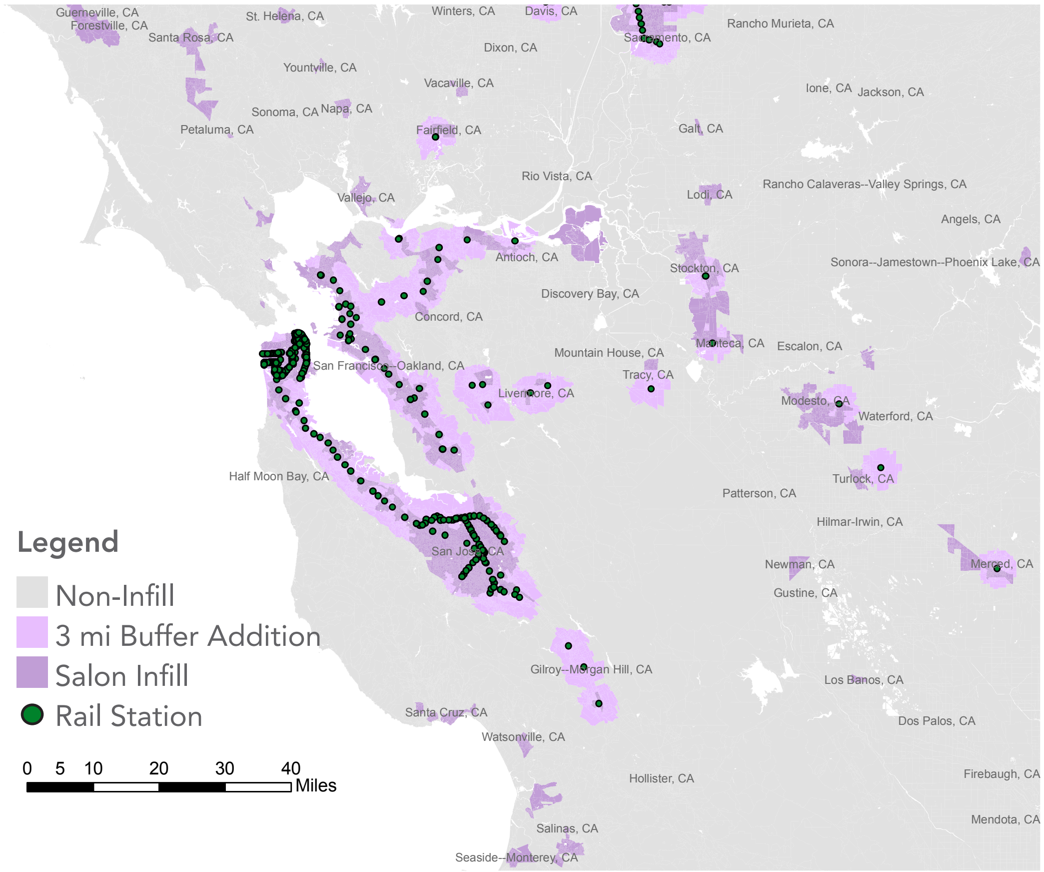
Figure 2: Infill Areas in California



Source: Authors' analysis after Salon et al. 2014 & Caltrans GIS Data Library Rail Data

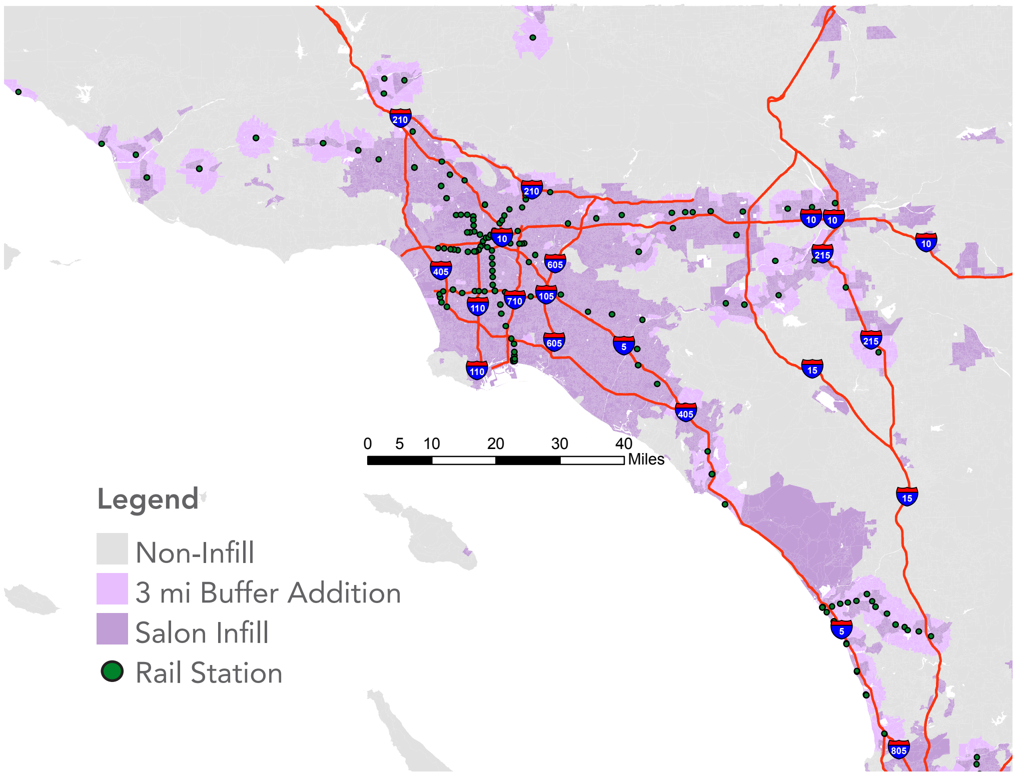
The boundaries of the infill areas become clearer at a smaller scale. The following series of maps, Figures 3-6, zoom in to a few of the larger metros in the state to show the definition of infill areas. Figure 3 shows the San Francisco Bay Area, highlighting not only the infill areas but also the regional rail system of the Bay Area Rapid Transit (BART) network and the stations for other rail lines, including the San Francisco MUNI system and Amtrak commuter lines. While most of the infill areas of the region are comprised by the densely populated areas around the bay itself, the inclusion of the buffer areas around rail stations also encompasses some farther-flung areas including Tracy, Livermore, and Gilroy.

Figure 3: Infill Areas in the Bay Area



Source: Authors' analysis after Salon et al. 2014 & Caltrans GIS Data Library Rail Data

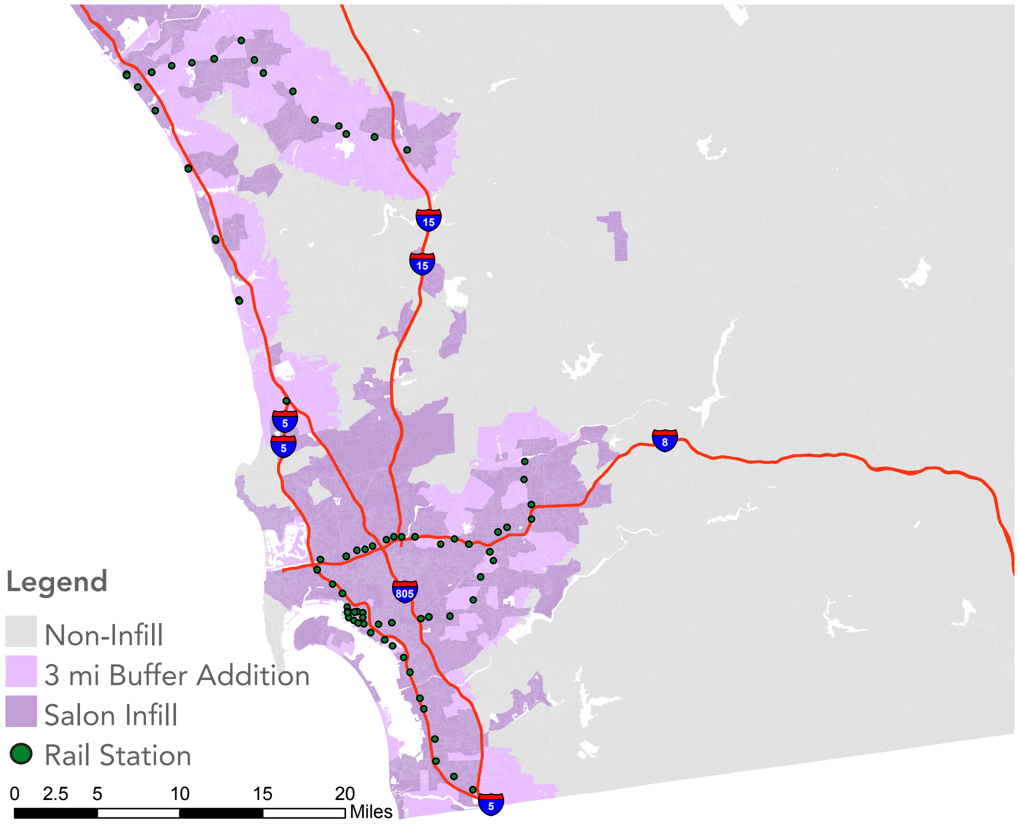
Figure 4: Infill Areas in Los Angeles



Source: Authors' analysis after Salon et al. 2014 & Caltrans GIS Data Library Rail Data

Figure 4 shows the infill areas in the Los Angeles metro area, identifying the major rail stations and major highways for reference. The L.A. metro area is by far the largest swath of infill area in the state, stretching from Simi Valley northwest of the City of Los Angeles, west to the city of San Bernardino, and south to San Clemente. Approximately 90% of the entire County of Los Angeles is infill under our definition. In addition to being geographically large, the L.A. metro area has grown rapidly since 2000. As a result, we project that a large portion of infill development will occur in this area of the state.

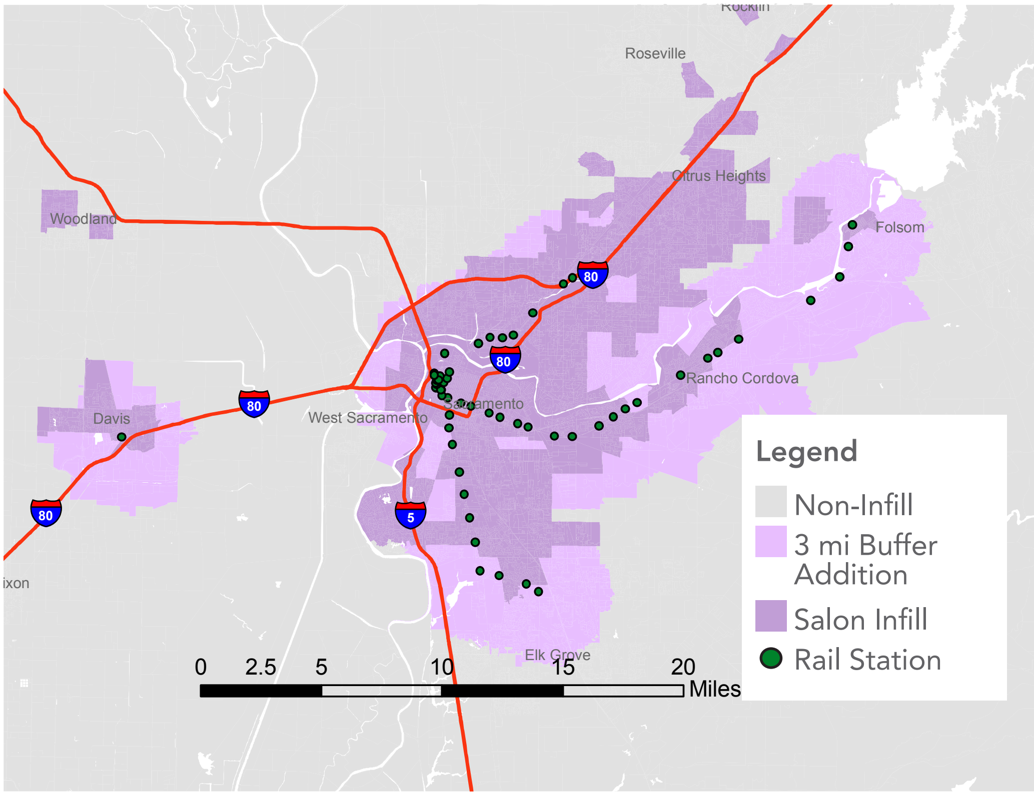
Figure 5: Infill Areas in San Diego



Source: Authors' analysis after Salon et al. 2014 & Caltrans GIS Data Library Rail Data

Figure 5 shows the San Diego metro area, another large area of infill in the state. Approximately 80% of the city of San Diego is infill, as defined in this study, as well as a majority of other large cities in the metro area, such as Chula Vista, Carlsbad, and San Marcos.

Figure 6: Infill Areas in Sacramento



Source: Authors' analysis after Salon et al. 2014 & Caltrans GIS Data Library Rail Data

While inland California generally has fewer infill areas, a number of larger cities have significant swaths. Figure 6 shows the infill areas of Sacramento. The Sacramento Regional Transit Light Rail network creates a large infill area under our definition, stretching north and east of the City of Sacramento up to Folsom lake.

In addition to dividing the state into infill and non-infill areas, we also make a coastal-inland distinction at the county level in our analysis. Construction costs, household utility use patterns, and home prices and rents all vary dramatically by this coastal-inland divide. Figure 7 shows the inland-coastal distinction.

Figure 7: Division of Coastal and Inland California

Source: Authors' analysis after Salon et al. 2014 & Caltrans GIS Data Library Rail Data

The divisions in the state geography therefore provide a four-category geographic classification of the state of California:

- Coastal Infill
- Coastal Non-Infill
- Inland Infill
- Inland Non-Infill

Scenarios

The analysis is based on three scenarios: (i) a business-as-usual Baseline Scenario that assumes the development patterns similar to the past 16 years, (ii) a Medium Scenario that assumes a significant increase in infill development, and (iii) a Target Scenario that assumes that all new residential development in the state will be in infill areas. We model growth in the state from 2015 to 2030. In addition to estimating changes in the location of development in the state, we also estimate the shift in building types of new residential development. We assume that different locations in the state (using the four-category locational classification) will be developed using a mix of building types that tracks the last 16 years of development, on average.

Table 1: Scenario Descriptions

Scenario	Units Produced 2015-2030	Description
Baseline	1,924,832	Development follows the same patterns as 2000-2015
Medium	1,924,832	Much more development occurs in infill areas than has historically ocurred
Target	1,924,832	All new development occurs in infill areas of California

We estimated the total projected housing construction through 2030 based on the California Department of Finance's population growth projections. The estimated production numbers assume only enough construction to accommodate the currently anticipated population growth. All of the scenarios assume a total housing production of 1,924,832 units. Given historical building trends in California demand could likely support far greater housing production than what we project in many areas of the state. This additional production could have the effect of improving affordability and reducing the rate of housing cost appreciation, though we do not model this possibility.

Table 2 shows the total production from 2015 to 2030 in the three scenarios by geography and building type. The Target and Medium Scenarios shift the state's housing production toward multifamily units in infill areas, particularly coastal infill areas. While rapidly rising rents for multifamily housing in coastal infill areas of California indicate high demand for this stock, this study acknowledges that many families prefer to live in single-family homes. National studies on neighborhood preference show the appeal of the detached single-family home. Yet these studies also show a strong consumer preference for walkable neighborhoods and proximity to jobs and schools.[18] Given that the Target and Medium scenarios produce approximately one million single-family detached units in infill areas, these scenarios should therefore be generally reflective of demand.

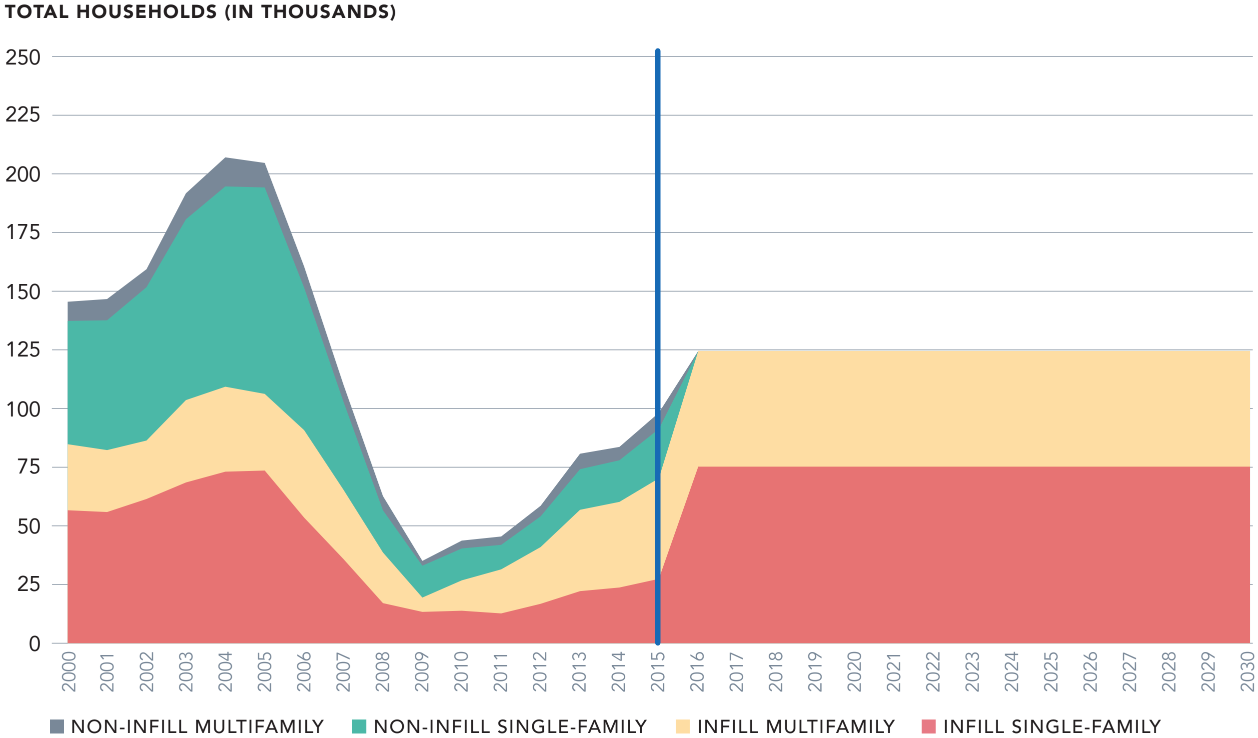
Table 2: Modeled Housing Production from 2015 to 2030 in Units by Location and Building Type

Baseline Scenario	Infill Coastal	Infill Inland	Non-infill Coastal	Non-Infill Inland
Single-family detached	199,024	246,792	238,693	518,205
Single-family attached & 2-4 unit	78,489	20,988	42,529	33,372
Multifamily low/midrise	305,196	52,096	101,480	60,433
Multifamily high-rise	27,533	0	0	0
Medium Scenario				
Single-family detached	305,447	378,758	119,347	259,102
Single-family attached & 2-4 unit	120,459	32,211	21,265	16,686
Multifamily low/midrise	468,391	79,953	50,740	30,216
Multifamily high-rise	42,256	0	0	0
Target Scenario				
Single-family detached	411,870	510,724	0	0
Single-family attached & 2-4 unit	162,430	43,434	0	0
Multifamily low/midrise	631,586	107,809	0	0
Multifamily high-rise	56,979	0	0	0

Figure 8 shows the actual and modeled housing production in California by aggregated building type and geography. The effects of the recent national boom and bust of the housing market are visible in California's sharp rise in housing production in the mid-2000s, followed by its precipitous fall starting in 2007. The total annual production levels in the state remain below their historical norms even in 2015. The chart also shows the overproduction of single-family, non-infill housing during the housing boom, as well as the shift of production to infill areas, particularly to multifamily in infill areas, since 2009.

Figure 8 demonstrates that the Target Scenario is not a major departure from historical volumes of housing production. But it does represent a major change in the siting of new development. The total annual projected volume of infill development, including multifamily development, is well within historical levels of production in California over the past 16 years. From 2000 to 2014, California produced 1,736,693 new units, approximately equal to the California Department of Finance's production

Figure 8: Annual Historical and Modeled Housing Production Under Target Scenario



Source: Authors' analysis after Construction Industry Research Board

estimate for 2015 to 2030. However, in the past 16 years, only about 60% of new development occurred in infill areas. The Target Scenario assumes that 100% of new residential development (approximately 1.9 million units) will occur in infill areas. Our identified infill areas are likely to have ample capacity to accommodate this level of development. According to a comprehensive study of the infill potential of the state, under-built parcels in infill areas could be developed or redeveloped to generate our modeled production.[19] While it is likely that infill areas will have the capacity to accommodate the projected levels of infill development, major policy changes will be required to ensure development happens in these areas as opposed to non-infill areas.

The scenarios model the effect of facilitating development in infill areas, though this shift has regional implications. Because there are more infill sites in coastal Southern California than in other regions of the state, the Target Scenario has the effect of generating more development in this area, particularly in the Los Angeles metropolitan area. This finding is in keeping with other studies that document the potential for infill housing in California.[20] This projection also mirrors the strong demand seen for homes in Southern California in the past decade.

Table 3: Regional Shifts in Housing Production from Baseline to Target Scenarios

	Baseline		Target		Difference	
	Coastal	Inland	Coastal	Inland	Coastal	Inland
North	18%	23%	19%	16%	+1%	-7%
South	33%	25%	47%	19%	+14%	-8%

A comprehensive study of the infill potential of California in 2005 by John Landis et al., funded by the State of California, indicates some of the practical implications of the Target Scenario. That study found that most of the potential for infill housing came from the redevelopment of under-built sites, not from the development of currently vacant sites. Using a definition of infill similar to ours, the authors found that of the approximately 4 million potential infill units, slightly less than 1 million could be constructed on currently vacant lots. Redevelopment could occur on land that houses a diverse mix of uses, primarily existing commercial and industrial (29%), multifamily (20%), other uses (20%,) and single-family (8%). The researchers expressed concerns about the affordability implications of this large-scale redevelopment. In addition, an October 2016 study by the McKinsey Global Institute on methods that the state could use to boost housing production also provided insight into the state's capacity for infill development. The study authors found capacity for (i) nearly a quarter million multifamily units on vacant urban land zoned for multifamily, (ii) 1.2 million potential units within a half-mile of transit hubs, and (iii) 800,000 units added to existing single-family homes.[21]

The Target Scenario in this study would not only entail the new construction of 1.9 million units but also the demolition and redevelopment of tens and perhaps hundreds of thousands of units. This report supports the concerns of the Landis et al. study that many of these units currently rent for below the median rents for their neighborhoods. For this reason, decision makers should consider adopting programs and policies to ensure that housing remains affordable to low- and moderate-income owners and renters, including the establishment of new programs and the expansion of existing programs, such as California's Affordable Housing and Sustainable Communities.

The analysis in this report does not examine the financial feasibility of the scenarios, which could be greatly affected by policy changes at the state and municipal levels that make infill development easier (a subject worthy of follow-up study). Using a broad analysis, the Landis et al. team found that 1.1 million of the 4 million potential infill units were "minimally financially feasible," meaning that a crude residual land-value analysis for multifamily development found a positive value for land. The analysis

Table 4: Comparison of Financially Feasible Infill Potential in San Francisco and Oakland with Target Scenario

	Dashboard Baseline Estimate	Dashboard Maximum Estimate	Target Infill Scenario
San Francisco	~ 37,000 units	~ 189,000 units	63,169 units
Oakland	~ 5,000 units	~ 84,000 units	23,111 units

Source: Authors' analysis of the Terner Center Housing Development Dashboard Policy Gauge

was conducted at the parcel-level but used highly aggregated market price and cost variations. For example, Los Angeles County was found to have 791,000 feasible units, while San Diego, Riverside, and San Bernardino counties had none, despite the substantial rental development underway at the time in these areas. The recent McKinsey study eschewed an analysis of financial viability entirely.[22]

The Terner Center's Housing Development Dashboard offers some insight on the financial feasibility of the Target Scenario.[23] This tool conducts a detailed residual land value analysis for multifamily development, to determine the approximate effect on multifamily production of changes in the market and local land use and housing policies. The Dashboard analyzes all underbuilt multifamily-zoned parcels within four jurisdictions: Oakland, San Francisco, Menlo Park, and Pleasanton. By comparing our anticipated production in the two large municipalities, Oakland and San Francisco, we can roughly estimate the financial feasibility of the Target Scenario in these municipalities. Because the Dashboard does not examine the feasibility of single family, 2-4 unit buildings, or very small multifamily development, the Dashboard estimates can be considered conservative relative to our Target Scenario production estimates, which include the development of small residential buildings.

Table 4 shows that the estimated production in Oakland and San Francisco is well within the financial possibility of these cities. The Dashboard shows that Target production in San Francisco could be reached by: (i) reducing permitting time from 18 months to 6, (ii) increasing density by 30%, and (iii) removing conditional use approval. The policy levers available on the Dashboard are not sufficient to produce enough multifamily housing in Oakland, however. In Oakland, either policy adjustments that are not available in the Dashboard, such as a change in zoning, or changes in the market, such as reductions in construction costs, would be necessary to generate the number of units in our target scenario.

The Dashboard results indicate that policy changes can make a significant difference to the financial feasibility of rental housing generation, particularly in coastal infill areas. Those policy changes will vary by municipality. In less expensive inland areas, different types of policy changes may be needed to encourage more infill development.

ANALYTICAL RESULTS

This study analyzes the three scenarios in order to evaluate their impacts on key metrics related to state environmental and economic goals.

These outputs offer a rough comparison of the costs and benefits of each scenario, showing that changes in the patterns of housing production can result in a reduction in greenhouse gas emissions along with a modest economic boost and a slight decline in many important household expenses.

CO2 Reductions: Vehicle Miles Traveled (VMT) and Household Utility Use

VMT Analysis

This analysis focuses on the VMT savings that can be produced by shifting residential development to infill locations across California. Research has generally found that neighborhood types have a distinct impact on travel behavior beyond simply attracting households that would drive less regardless of where they lived. Although scholars still debate the extent of that influence, studies suggest that of all the potential land use strategies to reduce VMT, boosting jobs-housing balance – which infill development can readily facilitate – is most effective.[24] Studies of VMT trends in transit-oriented developments in California, for example, have found that both employment and residential density in these nodes contribute to transit use (though job density was found to have a larger effect).[25] In addition, given the current robust demand for homes in infill areas of California in general, more infill residential development will likely lower VMT through both changing the behavior of residents and increasing the supply of homes in low-VMT neighborhood for buyers and renters who want to drive less. Furthermore, while this study focuses solely on new residential development, if these neighborhoods are accompanied by significant commercial infill development and major investments in transportation improvements (including walking, biking, and public transit), then the Medium and Target Scenarios could reduce VMT well beyond current neighborhood averages. Increasing infill commercial development would also provide other benefits, such as a potential increase in the per-square foot intensity of commercial development and jobs, which could result in a decreased demand for greenfield development.

A study on household carbon footprints by Jones and Kammen showed the complicated relationship between density and VMT.[26] In their nationwide analysis, they found that population density below 3,000 people per square mile is positively correlated with household carbon footprint. Beyond that threshold, however, population density is negatively correlated with household carbon footprints. Notably, the infill locations in this report based on Salon et al., discussed in more detail below, are above this critical density threshold, at 5,300 people per square mile. Jones and Kammen's analysis also modeled a variety of sources of greenhouse gas emissions, including transportation, food, and services. They found that VMT is the largest contributor to household greenhouse gas emissions, supporting the emphasis on this factor in this report.

Table 5: Weighted Average of VMT: Infill and Non-Infill Categorization of Neighborhood Types

Infill	VMT	Non-Infill	VMT
Urban, Low Transit Use	41.70	Suburb, Single Family Housing	59.66
Rural-In-Urban	41.09	Rural	50.27
Suburb, Multifamily Housing	40.99		
Urban, High Transit Use	26.80		
Central City	17.45		
Weighted Average	38.79	Weighted Average	57.24

Source: Authors' analysis after Salon et al. 2014

We calculate average household VMT for infill areas using an average of the constituent neighborhood types from Salon et al., weighted by the number of Census tracts per neighborhood type.

This finding suggests that infill households would drive about 18 miles less per weekday than non-infill households. By multiplying the household VMT reduction by the number of additional households in the infill locations relative to our Baseline, we calculated the greenhouse gas reduction resulting from the decreased household VMT. Reductions in VMT could also save time spent driving in traffic. Average trip speeds are often as low as 18 miles per hour, meaning this shift could provide families with an hour in their day that they no longer need to spend in their car – though it can be assumed that some of this time will be allocated to other forms of transportation.[27]

Table 6: VMT Reductions In Medium and Target Scenarios Relative to Baseline

	Maximum Annual VMT Reduction over Baseline Scenario	Maximum Annual Greenhouse Gas (GHG) Reduction from VMT Savings over Baseline Scenario
Medium	2,385,161,826 miles	0.80 MMT
Target	4,770,323,651 miles	1.61 MMT

Table 7: Household Utility Use by Scenario

	Baseline	Medium	Target
Household kWh/Month from Electricity	611.61	600.64	589.67
Household therms/Month from Gas	30.79	30.49	30.19
Household CO_2 Tons/Year from Utilities	3.48	3.44	3.39
Total Household CO_2 MM Tons/Year from Utilities	6.71	6.62	6.53

Source: Authors' analysis of CPUC data

Utilities Analysis

In addition to the decline in household VMT, we also expect lower household emissions from utilities. Our scenarios show that facilitating infill development will result in relatively more development in areas of the state with a milder climate and a shift to smaller units, both of which will reduce demand for energy for heating and air conditioning, which are generally the largest household energy uses. We estimate these effects in both dollars saved per month and avoided greenhouse gas emissions. Our Target Scenario shifts 269,920 more units to coastal areas over the Baseline Scenario, due to the increased prevalence of infill locations in those areas. The estimates below reflect some of the efficiency savings inherent to smaller units. And because our source utility data are based on the average home in a given area, those areas that already have smaller units and more multifamily structures will include additional building-type savings in addition to climate-driven savings.

Table 7 shows the estimated emissions savings associated with decreased utility use at the household level. When scaled up to all projected housing units across each scenario, this usage increases both our Medium and Target Scenarios' greenhouse gas emissions annual savings by about 10%.

These savings are conservatively calculated and thus likely an underestimate. The utility calculations are based on the average household's utility use at the county-level and reflect the current mix of housing units in that area. A shift to building smaller units in multifamily structures will also decrease utility usage due to shared walls and other efficiencies.[28] Furthermore, to the extent that the municipalities in infill areas have more stringent energy codes than non-infill municipalities, these codes could encourage further greenhouse gas reductions relative to the baseline.

Other Greenhouse Gas Effects of Infill Development

The estimate for greenhouse gas reductions from concentrated infill may be conservative for multiple reasons. This study:

- focuses only on new residential development without examining the effects of demographic shifts in demand, improvements to transportation infrastructure, and infill commercial development;
- examines only weekday VMT changes, though weekend VMT may also diminish in our Medium and Target Scenarios;
- does not examine the effect that the replacement of older units with newer units that will occur through redevelopment will have on household utility use, which may be significant given improvements in building energy efficiency;
- only seriously examines VMT and household utility use, not other sources of greenhouse gas emissions, such as household consumption patterns for food, other goods, and services, which can be significant generators of emissions; [29] and
- does not examine the extent to which business-as-usual patterns of residential development could be expected to release (or stop the process of) carbon currently sequestered in forests, grasslands, or agricultural lands.

Similar analyses conducted by large state and regional agencies show the potential magnitude of the above effects. Among the state's many climate change initiatives, SB 375 promotes greenhouse gas reductions through coordinated land use and transportation planning by the state's 18 Metropolitan Planning Organizations (MPOs). The SB 375 emission reduction targets, developed by the California Air Resources Board (CARB) in consultation with the MPOs, propose an annual statewide reduction of 3.4 and 15.1 million metric ton (MMT) CO2 in 2020 and 2035 respectively.[30] These targets lead to an annual reduction of approximately 11 MMT CO2 in 2030 to be on track to meet the 2035 goal.

A 1.79 MMT annual reduction for the Target Scenario, as found in this study, represents almost 15% of the savings needed to reach the SB 375 targets (though the California Air Resources Board is likely to increase the greenhouse gas reduction targets for Sustainable Communities Strategies plans under SB 375 to achieve statewide 2030 greenhouse gas reduction goals).[31] The potential reductions calculated here do not include savings that have already been achieved since the passage of SB 375 in 2008, or savings from the non-residential land use sector (such as commercial development), which would further boost emissions reductions closer to the statewide targets.

The analyses from many of the state's MPOs are at the parcel level and are not limited to the siting of residential development. Their simulations suggest that 11 megatons of CO2 reduction can be achieved with more infill development contemplated under SB 375, as described above.

Furthermore, the greenhouse gas savings found in the Target Scenario are equivalent to averting emissions from 378,108 passenger vehicles and from burning over 201 million gallons of gasoline annually.[32] This reduction is also equivalent to almost two-thirds of the total statewide emissions decrease California achieved between 2013 and 2014 alone, representing a 6 percent decrease over peak 2004 levels. Together with other land use changes that this housing scenario could stimulate, the emissions savings would help the state meet its goals of reducing emissions from a projected 431 million metric tons in 2020 to 260 million metric tons by 2030, as required by state law.[33]

Construction Costs

This study projects little difference in aggregate residential construction costs in the Target Scenario relative to the business-as-usual Baseline Scenario. The cost of generating enough housing to accommodate the state's growth from 2015 to 2030 is 2% lower in the Target Scenario relative to the Baseline Scenario, despite the significant differences between the scenarios in the location of units and building type. For example, the Target Scenario would generate approximately 250,000 more multifamily units than the Baseline Scenario, and low- and mid-rise multifamily units are approximately 15% cheaper to construct than single-family detached units. This cost difference arises from the smaller size of multifamily units. Though more expensive on a per-square-foot basis, we assume an average size for multifamily units of 800 square feet, compared to 2,000 square feet for an average single family home. The regional differences are equally large, with the Target Scenario assuming the development of 255,000 more units in coastal Southern California than the Baseline Scenario. Overall, construction costs are approximately 12% less expensive in coastal Southern California relative to coastal Northern California.

These potential sources of savings, however, are attenuated because of other shifts in the location and building types. In the Target Scenario, proportionally more development would occur in coastal and southern areas. We find that coastal areas have slightly higher building costs than inland areas. While the cost difference between coastal and inland areas is not as stark as the north-south cost difference, it is large enough to eliminate the savings gains from the southward shift. Similarly, the savings gained from the shift to attached single-family and low- and mid-rise multifamily are nearly eliminated by the increase in the prevalence of relatively more expensive high-rise multifamily housing.

Construction costs drive the economic outputs of this analysis, and variations in these scenarios lead to construction cost differences that in turn result in uneven economic effects. For example, shifting development to coastal Northern California will dramatically increase overall construction costs (inland Northern California also has construction costs that are relatively high in the state). The impact of building type mix also affects construction costs. While single-family homes and attached and 2-4 family homes are cheaper than multifamily to build on a per-square-foot basis, multifamily apartments tend to be smaller. If multifamily homes increase in size, or if the building mix of multifamily includes more high-rise buildings, the aggregate construction costs of the Target and Medium scenarios will rise relative to the baseline. These higher construction costs will boost the state's economy, but they will limit the financial feasibility of new construction.

Unlike the CBIA study referenced previously, this study does not estimate the increased costs of the state's increasingly stringent energy code standards. As discussed, the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) intend to require that most new residential construction be zero net energy (ZNE) starting in 2020.[34] This report did not estimate the cost effects of these requirements because those impacts are highly uncertain. For example, the CPUC and CEC indicated that the multifamily sector will face higher energy efficiency and production standards but will not be required to be ZNE. The absence of firm standards for multifamily alone makes estimating the cost effects on this stock impossible at this stage. Furthermore, as discussed, the costs of solar panels and the cost increment of energy efficiency measures for single-family homes (required for ZNE) are currently diminishing as these technologies and construction techniques become more widespread. Therefore, this report based construction cost estimates on current data and has put aside the impact of CPUC and CEC's future energy code changes until they are defined.

This analysis focuses on the cost impacts of infill on regional patterns of housing production and building type. These variations are important but do not fully account for all the changes that could affect the costs of residential development in the Target Scenario. The most complicated is the potential cost difference between infill and greenfield development, which is highly variable by site. The costs of building infill can vary and be substantial. Most commonly these costs include large-site

Table 8: Total 15-Year Construction Costs by Location and Building Type ($billion)

Baseline	North Coastal Infill	North Inland Infill	North Coastal Non-infill	North Inland Non-Infill	South Coastal Infill	South Inland Infill	South Coastal Non-Infill	South Inland Non-Infill
Single-family detached	23.3	44.4	43.3	97.8	51.2	45.7	46.6	92.5
Single-family attached & 2-4 unit	8.7	3.6	7.3	6.0	19.2	3.7	7.9	5.7
Multifamily low/midrise	30.1	7.9	15.5	9.6	66.1	8.1	16.9	9.1
Multifamily high-rise	3.3	0.0	0.0	0.0	7.2	0.0	0.0	0.0
Total: 680.4								
Medium								
Single-family detached	35.8	68.1	21.6	48.9	78.7	70.2	23.3	46.3
Single-family attached & 2-4 unit	13.4	5.5	3.7	3.0	29.4	5.7	3.9	2.8
Multifamily low/midrise	46.2	12.1	7.7	4.8	101.5	12.5	8.3	4.5
Multifamily high-rise	5.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0
Total: 673.9								
Target								
Single-family detached	48.3	91.8	0.0	0.0	106.1	94.6	0.0	0.0
Single-family attached & 2-4 unit	18.1	7.4	0.0	0.0	39.7	7.6	0.0	0.0
Multifamily low/midrise	62.3	16.3	0.0	0.0	136.9	16.8	0.0	0.0
Multifamily high-rise	6.7	0.0	0.0	0.0	14.8	0.0	0.0	0.0
Total: 667.5								

preparation, including demolition costs and site remediation costs, which can be high particularly for brownfield sites. Greenfield development also has additional costs, particularly the construction of new infrastructure (including sewer, water, and transportation improvements). While case-by-case comparisons can show large cost differences in favor of either infill or greenfield development, our conversations with developers indicated that these additional costs, on aggregate, would not necessarily favor one location over the other. This analysis does not consider land costs, for example, which could be expected to be generally higher in infill areas relative to non-infill areas. We also do not measure the effects of local regulations on construction costs, including permitting fees, the costs of the entitlement process lengthening development timelines, impact fees, and other added costs that could have a significant impact on residential construction costs. Furthermore, we do not estimate the additional construction activity (and its positive impacts on the local economy) that will occur due to the redevelopment of existing units that will need to be demolished and rebuilt under our scenarios.

We also have limited data on spatial variations in construction costs. While private and public sources offer a number of large-sample data products on rents and home prices, data on construction cost variations are only available from private firms and use smaller sample surveys. This study uses data from RS Means, a company that conducts regular surveys of developers and then aggregates and curates the information to produce widely used data on construction. While RS Means is the best source for data at the scale of the state, constructions costs can vary dramatically at much smaller scales than what RS Means surveys can capture. Despite the limitations of this analysis, a major shift in the regional production patterns and building type mix in the state does not appear likely to increase the cost of constructing homes to accommodate new residents in California.

Economic Effects: Jobs, Income, & Growth

The analysis of the economic effects of infill development produces two significant findings: (i) that residential development, particularly multifamily development, provides an economic boost to the state's economy, and that (ii) encouraging infill development may not have a large effect on the size or nature of this impact. Table 9 below shows detailed findings on (i) job growth, (ii) wage income growth, and (iii) state and regional economic growth. Across scenarios, simulated annual residential production will generate approximately 500,000 new jobs, each of which pays approximately $51,000, with a total annual economic impact on the state that is 74% to 80% higher than the direct construction investments, providing a total boost to the state's economy of approximately $80 billion.

In this economic analysis, the scenarios vary only on (i) the total aggregate residential construction cost and (ii) the ratio of single-family to multifamily construction. The larger the aggregate costs, the more jobs will be produced and the greater the economic output. Because the scenarios vary only slightly in aggregate construction costs, all three of the economic variables differ by less than 3% among the scenarios. The slight reduction in construction costs gained from the Target Scenario is reflected in the slightly fewer jobs generated. The effects of the mix of single-family and multifamily construction are more nuanced. Despite generating slightly fewer jobs, the Target Scenario produces larger collective wage income because the shift to multifamily construction demands more skilled labor than single-family construction. Economic multipliers for multifamily construction are higher than single-family construction, as the Target Scenario produces a total economic impact 80% greater than the total construction costs, compared to a Baseline Scenario that provides 74% more growth.

Table 9: Annual effects of residential development

Baseline	North Coastal	North Inland	South Coastal	South Inland	Total
Total Employment	81,578	130,055	165,531	117,398	494,561
Total Labor Income	$5,402,891,808	$5,844,278,270	$8,930,776,671	$5,044,541,434	25,222,488,183
Total Economic Output	$15,264,577,678	$19,182,710,676	$27,510,476,321	$17,056,346,798	79,014,111,473
Medium					
Jobs	83,346	109,554	198,111	101,230	492,240
Income	$5,524,981,826	$4,923,931,867	$10,694,696,051	$4,350,093,996	25,493,703,740
Total Economic Output	$15,599,206,665	$16,164,100,042	$32,946,006,986	$14,708,990,595	79,418,304,288
Target					
Jobs	85,115	89,053	230,691	85,062	489,920
Income	$5,647,071,845	$4,003,585,465	$12,458,615,431	$3,655,646,558	25,764,919,299
Total Economic Output	$15,933,835,651	$13,145,489,408	$38,381,537,650	$12,361,634,392	79,822,497,101

This analysis is probably a conservative estimate of the economic benefits of infill development. As discussed in the construction costs section, the estimates above do not show the effect of the redevelopment of units. This increased cost will mean that, on average, infill projects will have a far greater economic impact on a per-new-unit basis.

Lastly, by focusing on residential development, this study does not account for what could be a profound agglomeration economy effect arising from increased job density. Numerous studies have shown that job density can significantly increase the productivity of workers and firms.[35] Economists have demonstrated a number of means by which this occurs, including the rise in innovation that occurs with job density and the development of clusters of distinct but related firms that collectively support each other through interconnected exchanges of goods and services.[36] Even a small increase in the local productivity of workers or firms could have a significant impact on the total economic growth in the region or state. As a result, the estimates in this study are likely conservative.

Fiscal Impact

Each scenario in this study is estimated to generate $3.8 billion in annual state and local tax revenue. The majority of this revenue will be from property and sales taxes. The analysis shows nearly no variation in revenue by scenario.

This analysis of probable fiscal impacts of the Target Scenario is limited in scope for three reasons: (i) we only consider residential development, (ii) we are only able to conduct the analysis at the level of municipalities and regions, not parcels, and (iii) we lack means of assessing the current excess infrastructure and service capacity across California. Residential development is generally a fiscal loss for local governments, as new residents require relatively costly government services such as schools, police and recreational services, while providing government with property tax, fees, and, occasionally, income tax revenue that rarely cover these costs.[37] A complete analysis of the fiscal impact of residential development alone would likely produce findings that showed not whether development was a net fiscal positive, but rather the extent of losses in different scenarios. While we do not estimate fiscal costs, the relatively meager per-capita revenues (about $1,127 annually) are unlikely to cover state and local costs, which may be as high as $5,188.[38] The analysis includes only gross regional changes in residential development patterns and shifts in building type and does not reveal the potentially large difference in the assessed values of the average infill home relative to the average non-infill home, as well as the increased property tax revenue from replacing older, under-assessed property with new infill development. A parcel-level analysis could more precisely determine the difference in revenue, particularly from property taxes. Lastly, the biggest potential fiscal benefit of infill development is the ability for new development to use existing capacity in government-provided services and infrastructure. This critical variable is difficult to measure across the state.

Conflicting evidence clouds the probable effect of the Medium and Target Scenarios on local government expenses and revenues. A fairly large academic literature on the effect of residential densities on local government expenses and revenue has produced mixed findings. Major studies in the 1990s found a “U-shaped” relationship between density and fiscal costs, with a fiscally optimal level of density at around only 250 people per square mile.[39] More recent national studies that examine the most costly state and local expenditures have found that denser development at the county level is in general associated with lower per-capita fiscal costs.[40] Many authors note the tension between the large cost savings that come from using already available infrastructure and service capacity and the potentially high costs of supplementing existing capacity required for new development. Studies also grapple with the large variations in principal revenue sources among local governments, particularly by state. While property and sales tax revenues are generally the largest sources, they vary dramatically by municipality, while some municipalities have other substantial sources of revenue associated with development, such as permit or impact fees.

A detailed county-level study of the United States found that while in general the fiscal impact of compact residential development was less negative than the fiscal impact of sprawling residential development, counties faced a slightly larger negative fiscal impact for residential development in a compact scenario relative to a sprawl scenario in California.[41] This difference is particularly pronounced in Southern California.[42] The reasons are not immediately clear, though California's property tax restrictions and dearth of under-utilized urban infrastructure relative to other parts of the country may account for some of this difference. The authors note only the "revenues and higher-cost services systems" in the western United States in general.[43]

While the studies above suggest that the Target Scenario may result in larger fiscal losses relative to the Baseline Scenario, commercial infill development, which this study does not examine, has the potential to offset even a large negative net fiscal impact from residential infill development. Analysis has shown that concentrating commercial development in downtown areas provides high per-acre tax revenue relative to more dispersed commercial development.[44]

The larger issue is the perverse fiscal incentives that reward municipalities for commercial development and punish them for providing their fair share of housing. California's tax system, which post-Prop 13 in 1978 reduced property tax rates, may have the effect of promoting sprawling development and worsening jobs-housing imbalances in localities. Better alignment of the state's tax systems with climate change and development goals could involve regional tax sharing, land (as opposed to property) taxes, linkage fees such as a carbon tax, or a tax on commercial development that is directed to workforce housing production. Alternatively, at a minimum, policy makers could reform tax policy to avoid penalizing residential development.[45] See the policy recommendation section for more details.

Household Utility Costs

This study conservatively estimates a small savings in per household utility costs in our Medium and Target Scenarios compared to the business-as-usual Baseline Scenario. Across all the housing production scenarios though, consumer savings equal almost $10 million annually between our Baseline and Target Scenarios.

Table 10: Average Utility Costs by Scenario

	Baseline	Medium	Target
Monthly Household Utilities	$149	$146	$144
Total Annual Household Spending on Utilities	$286,799,968	$281,025,472	$277,175,808

Source: Authors' analysis of CPUC data

These savings reflect the decreased need for utilities, particularly for energy-intensive heating and air conditioning, in milder coastal climates. As discussed above, however, these cost savings are likely an underestimate. The source data reflect the current housing unit make-up in each of the four location classes, including both the savings from a milder climate and the efficiencies of smaller units and multifamily structure savings. As the share of smaller units and multifamily structures in the housing mix increases, residents are likely to see additional cost savings.

Table 11: Average Household Transportation Costs by Scenario

	Baseline	Medium	Target
Monthly Household Transportation Costs	$1,109	$1,080	$1,051

Source: Authors' analysis of CNT's H+T Index

Household Transportation Costs

Both the Medium and Target Scenarios produce savings in monthly household transportation costs over the business-as-usual Baseline Scenario.

This output comes from the Center for Neighborhood Technology's transportation cost data, which include auto ownership costs, auto use costs, and transit costs.[46] While the database does not reveal the relative importance of each of these factors, some likely contributions are based on changes in the location of development across our four locational categories.

Table 12 Average Household Transportation Costs by Location

	Coastal Infill	Inland Infill	Coastal Non-Infill	Inland Non-Infill
Monthly Household Transportation Costs	$1,024	$1,104	$1,145	$1,173

Source: Authors' analysis of CNT's H+T Index

Table 12 shows how estimates for monthly household transportation costs differ across our four geographies.

For both coastal and inland locations, transportation costs decrease in infill locations compared to non-infill locations. The estimates demonstrate that these locations are characterized by 6-11% lower household transportation costs, which likely result from lower rates of auto ownership, lower costs for auto owners who drive fewer miles, and an increase in trips made on foot, by bike, or by comparably more affordable public transit. Additionally, as the infill areas increase in density and additional investments in public transit come online, access to services and opportunities in these areas will continue to increase and could further reduce transportation costs for households in these places.

Housing Costs

Demand for housing is generally higher in coastal and infill areas in California, relative to inland and non-infill areas. To estimate the impact of this increased demand on housing sales prices and rents of units in the scenarios, we use historical home price and rent cost data from Zillow and the U.S. Census. Table 13 shows the variations in prices and rents by location.

Table 13 Average Home Prices and Rents by Scenario

	Average Home Price per Square Foot	Average Monthly Rent per Square Foot
Coastal Infill	$331	$2.30
Inland Infill	$143	$1.08
Coastal Non-Infill	$290	$2.03
Inland Non-Infill	$144	$1.14

Source: Authors' analysis of CNT's H+T Index

Inland locations have almost no difference in cost between infill and non-infill areas. But infill units in coastal areas sell and rent at 10-15% more than coastal non-infill areas.

Allocating units across the state under the three scenarios provides the price pattern per square foot show below. Because development in the Target Scenario is concentrated in high-demand areas, the prices per square foot are much higher than the Baseline.

Table 14: Average Home Prices and Rents per Square Foot by Scenario

	Baseline	Medium	Target
Average Home Price per Square Foot	$221.52	$236.79	$253.64
Average Monthly Rent per Square Foot	$1.61	$1.70	$1.80

Source: Authors' analysis of Zillow data

However, these cost increases are attenuated when modeling the development by building types in the scenarios. Because we project more multifamily development with smaller units, the price difference per unit is less than the price per square foot, as shown in the table below. We scale these estimates up to produce a housing cost for either a for-sale home or unit for rent. Larger units, or a shift away from multifamily to single family housing, will produce on average more expensive housing.

These estimates do not try to capture the price effects of adding more supply to the market. Recent reports from the California Legislative Analyst's Office suggest that an increase in housing supply could help to stabilize or bring down housing costs.[47]

While we expect to see average housing rents and prices increase in our Target Scenario, these household cost increases are effectively negated by the household savings in utility and transportation costs. Table 16 shows that the cumulative largest household expenses of housing, transportation, and utilities only differ by less than 1% from the Target to the Baseline Scenario.

Table 15: Average Home Prices and Rents by Scenario

	Baseline	Medium	Target
Average Home Price	$367,527	$374,439	$381,350
Average Monthly Rent	$2,666	$2,684	$2,702

Source: Authors' analysis of Zillow data

Table 16: Average Home Prices and Rents by Scenario

	Baseline	Medium	Target
Monthly Household Utilities	$149	$146	$144
Monthly Transportation Costs	$1,109	$1,080	$1,051
Average Monthly Rent	$2,666	$2,684	$2,702
Average Home Price	$367,527	$374,439	$381,350
Average Monthly Mortgage Payment*	$1,431	$1,458	$1,485
Total monthly renter expenses (rent + transportation + utilities)	$3,924	$3,911	$3,898
Total monthly owner expenses† (mortgage + transportation + utilities)	$2,573	$2,567	$2,560

* Assuming an 80% LTV, 30 year FRM at Freddie Mac January 2017 rate of 4.16%
† Not including property taxes or property insurance

POLICY RECOMMENDATIONS

Should policy makers wish to see the Target Scenario become reality by 2030 (or to move toward the Medium Scenario), they will need to take a mix of actions today by both providing incentives and removing restrictions.

Since land use decisions are primarily local in nature, these officials will be the prime actors to allow more housing in the appropriate locations. Each community will have different challenges to address: in some communities, market demand for infill housing is thwarted by local land use restrictions, while other communities that lack demand will need more incentives and subsidies for development to catalyze more private investment. Similarly, the types of policies in each community that thwart infill development can vary, from parking requirements in some to restrictive zoning in others. State leaders, meanwhile, can help by directing state dollars to infill areas and minimizing the permitting process for appropriate projects in low-VMT areas.

Policy makers will need to be particularly sensitive to issues of equity. Further displacement of economically disadvantaged residents should be mitigated by appropriate policies, such as boosting affordable housing supply in at-risk neighborhoods.[48] Redevelopment of existing neighborhoods should also ensure mitigation for any displacement, whether direct or indirect (due to housing price increases).[49] And in the long run, more market-rate housing today will boost the unsubsidized affordable housing stock of tomorrow.

The solutions below represent the most prominent options to boost infill housing in low-VMT parts of the state, based on our survey of existing literature. While this study did not attempt to link any particular policy to additional increments of housing in each scenario, the options below are in part based on sources like UC Berkeley's "Dashboard," which conducts that analysis at the local level.

To implement the Target and move toward the Medium Scenarios, local leaders in prime infill areas should consider:

Reforming the local land use regulatory regime to promote responsible residential growth in infill areas (the October 2016 McKinsey study suggested that over five million units could be developed in infill areas through a set of reforms that promoted the development of accessory units or "granny flats," the redevelopment of underbuilt parcels, and the new development of parcels adjacent to existing development and job centers).[50] Reforms could include:

- Shortening overly lengthy permitting timelines;
- Changing zoning to allow for more multifamily use;
- Reducing/suspending/eliminating ground-floor retail requirements in areas with low retail rents;
- Reducing parking requirements when feasible;
- Increasing allowable density where feasible;
- Implementing anti-displacement policies, such as preservation of affordable housing, tenant harassment protections, and guarantee of lease renewal;
- Establishing local and regional financing mechanisms for infrastructure investments;

Improving transit service and infrastructure in prime infill areas:

- Directing more funds to rail and bus rapid transit investments in infill areas;
- Improving bus and other connections to rail and bus rapid transit, including through enhanced biking and pedestrian infrastructure; and

Developing urban growth boundaries to protect critical open space and farmland from further development and environmental degradation, provided additional incentives for infill development and housing affordability are simultaneously in place

State leaders should consider:

Encouraging local action to permit more responsible infill development, such as through:

- Developing a state program modeled on Massachusetts' "Chapter 40B Housing," in which developers can override local zoning bylaws for housing production in municipalities that do not meet regional affordability targets;
- Reducing local parking requirements in infill areas;
- Providing more property tax to municipalities that generate housing in low VMT neighborhood types;
- Establishing a regional tax-sharing system with benefits to municipalities that meet regional housing goals;

- Creating demand-side programs for infill housing, such as rebates or down-payment assistance for homes in low VMT neighborhood types
- Supporting urban growth boundaries to protect critical open space and farmland from further development and environmental degradation, provided incentives for infill development and housing affordability are simultaneously in place;

Increasing funding for affordable housing, such as through bolstered "affordable housing and sustainable communities" (AHSC) funding from cap-and-trade auction proceeds and infrastructure finance programs;

Improving transportation and transit investments in prime infill areas by:

- Developing transportation pricing strategies to facilitate reductions in VMT, while ensuring that low-income families do not face an undue cost burden;
- Directing more funds to rail and bus rapid transit investments and operations in infill areas, such as the Transit and Intercity Rail Capital Program;
- Improving bus and other connections to rail and bus rapid transit, including through enhanced biking and pedestrian infrastructure;
- Developing project performance standards for all state infrastructure facilities to prioritize proposed projects based on their estimated performance reducing overall vehicle miles traveled and greenhouse gas emissions; and

Ensuring that the California Environmental Quality Act (CEQA) provides more certainty and streamlined processing for infill projects that meet state environmental goals.

CONCLUSION

California's residential housing sector will be key to achieving the state's economic and environmental goals through 2030 and beyond.

This study describes the costs and benefits of taking a more proactive role to encourage the right type of housing in the right places. It represents the first comprehensive research approach to describing various housing scenarios and their likely impacts on key economic and environmental indicators. Major policy shifts are necessary in order to spur infill development, and future research should model the effects of the policies recommended in order to identify the most effective.

Further research on the financial feasibility of these scenarios, as exemplified by the Terner Center's "Dashboard" at the local level, would give the public more information about what policies would be most helpful to achieve the desired scenario. For example, where appropriate development is financially feasible, policy makers should focus on removing land use restrictions in these areas. Where desired development is infeasible, policy makers should either focus incentives and funding in these areas or re-examine the target statewide housing mix to adjust for economic realities.

Further research could also cover parcel-level analysis to help refine the conclusions offered here, such as the likely increases in property tax revenue, and provide more granular insight into the scenarios and likely outcomes. And expanding the study to look at commercial development, as well as a closer examination of redevelopment opportunities, would give the public a more comprehensive look at how neighborhood-scale development of all types could boost California's economic performance and environmental sustainability.

Ultimately, California policy makers at the state and local levels will need to demonstrate a willingness to tackle the housing challenges in the state. The significant housing shortage and lack of low-VMT neighborhoods in the state is not necessarily the result of a free market, but rather the combined impact of numerous policies at multiple levels of government, over multiple decades, that have served to constrain supply and push growth toward the environmentally sensitive edge of communities. Policy makers will need to assess the causes of this situation and take steps to remedy it, in order to guarantee continued economic prosperity and environmental stewardship in the state.

METHODOLOGY

Definition of Infill

While there is no standard, generally accepted definition of what constitutes "infill" development in the US in general or California in particular, there are a number of well-researched attempts to identify what is and isn't infill. In a comprehensive assessment of California's capacity for infill housing Landis et al. delineated three progressively restrictive definitions of the term, referring to them as Largest, Middle, and Smallest Counting Areas. Using Census blocks as the unit of analysis Landis et al. established these definitions of infill based on (i) unit per acre minimums, (ii) presence in an incorporated city, (iii) previously defined commercial and industrial areas.[51] Other analyses have used Census-designated urbanized areas as definition of infill development.[52] The Census uses Census block and tract density and total population in their standards for urbanized areas.[53] The California Air Pollution Control Officers Association defined infill locations based on (i) levels of transit series and (ii) neighborhood centrality (e.g. center city, inner ring suburb, etc.).[54] The State of California has also put forward a definition in SB 375, SB 226, and SB 743.

> "Infill site" means a lot located within an urban area that has been previously developed, or on a vacant site where at least 75 percent of the perimeter of the site adjoins, or is separated only by an improved public right-of-way from, parcels that are developed with qualified urban uses.[55]

"Urban Area" is defined in CPRC § 21094.5 as:

> Includes either an incorporated city or an unincorporated area that is completely surrounded by one or more incorporated cities that meets both of the following criteria:
>
> - The population of the unincorporated area and the population of the surrounding incorporated cities equal a population of 100,000 or more.
> - The population density of the unincorporated area is equal to, or greater than, the population density of the surrounding cities.[56]

While a "Qualified Urban Use," according to CPRC § 21072, is:

> any residential, commercial, public institutional, transit or transportation passenger facility, or retail use, or any combination of those uses.[57]

The definition of infill used in this paper is based on what is currently the most comprehensive study of the correlation between California neighborhood types with VMT of residents of those neighborhood types. This study was commissioned by the California Air Resources Board and the California Environmental Protection Agency and performed by Salon et al. [58] The study first performed a cluster analysis of all Census tracts in California using 11 variables such as population density, road density, and age of

Table 17: Summary Statistics for Infill Definition

	# of acres	% of state	# of units	% of units
Low VMT Areas	2,816,462	3%	8,552,233	63%
3 mi Rail Buffer	1,135,876	1%	1,287,637	9%
Salon + Buffer	3,952,338	4%	9,839,870	72%

housing stock. This analysis identified 7 neighborhood types, such as rural areas, central cities, and suburbs that were primarily single-family housing. 5 California travel surveys conducted from 2000 to 2009 were then aggregated, weighted to adjust for varying response rates, and analyzed using the neighborhood types to reveal differences in household weekday VMT patterns by neighborhood type. We further aggregated these neighborhood types into two categories: (i) infill tracts, which have below average VMT, and (ii) non-infill tracts that have above average VMT.

We then added tracts with centroids within 3 miles of train stations that provide 3 or more round-trips every weekday. We added these areas because existing rail stations are a major opportunity for infill development even if they did not show the low-VMT characteristics of infill areas in the 2000s. The table below shows the total land area of the state that we define as "infill" and the number of housing units in this area. As expected our infill areas are far denser than average for the state, encompassing only 4% of the state's land area, but nearly 75% of its housing stock.

As the rail network in California continues to develop, new stations could present opportunities for additional infill development. We used rail station locations for the following lines:

- ACE (Altamont Commuter Express running Stockton to San Jose)
- Amtrak intercity routes (Capitol Corridor, San Joaquin, Pacific Surfliner)
- BART
- Caltrain
- Metro LR (Los Angeles)
- Metrolink (SoCal intercity rail)
- MTS (San Diego Trolley system)
- MUNI LR
- NCTD (San Diego intercity rail/LR)
- Sacramento Regional Transit LR
- Santa Clara VTA LR

Finally we distinguish coastal California from inland California using home prices and rents, which is the sharpest difference between these areas of the variables that we consider. We define coastal counties as counties that are either:

- In the top quartile of county median rent or
- Have a median 2010-2014 home price over $325k

We use median rent data from the 2014 American Community Survey and Zillow for median home values.[59]

Scenarios

Our scenarios model the effects of facilitating residential development in infill areas of the state. To establish a business-as-usual Baseline Scenario we used data on permitting activity from 2000 to 2015 from the Census Building Permit Survey to estimate building patterns across the state.[60] These data are aggregated at the municipality level, so we were unable to precisely measure the division between infill and non-infill development in municipalities that were not either completely infill or completely non-infill. In divided municipalities we assumed that past construction was split according to the portion of Census blocks that were infill or non-infill within the municipality. For example approximately 80% of the Census blocks in Pittsburg in Contra Costa County are infill, so we assumed that of the approximately 5,000 units permitted in Pittsburgh from 2000 to 2015, approximately 4,000 were permitted in infill areas. We also apportioned development at regional level distinguishing between inland and coastal areas. We assume that future patterns of development will mirror past patterns within the geographic categories that we have established. For example we anticipate that in the Target Scenario LA will generate about 50 times more units than Berkeley, as LA produced 50 times more housing than Berkeley during the past 16 years, and as both cities are effectively 100% infill.

Our Target Scenario models the impact of having all new residential development occur in infill areas of the state. Our Medium Scenario is precisely between the Target and Baseline Scenarios, directing half as much new residential development to infill areas as the Target Scenario does, relative to the Baseline.

We also show the practical effect that this shift in the location of development will have on the types of buildings that will be constructed. Building type has major implications for construction costs, the economic impact of construction, the types of labor used in construction, and the final rental and sales prices. For this analysis we model four building types: (i) single family detached homes, (ii) single-family attached homes and 2-4 unit buildings, (iii) mid-to low-rise multifamily building of 7 stories or less and (iv) high-rise multifamily of over 7 stories. We bundle 2-4 unit buildings with single family attached because 2-4s are a very small part of new construction, comprising less than 5% of all new units. We distinguish between low- and mid-rise multifamily and high-rise multifamily largely because it is much more expensive to build high-rise multifamily buildings. In California new buildings can be constructed with 5 floors of wood-framed structure above a 2-story reinforced concrete podium. Taller buildings must be type I construction made primarily of reinforced concrete or structural steel. This method of construction is 30% more expensive than constructing lower-rise buildings on a square foot basis.[61]

Many studies of infill residential development focus solely on multifamily. We assume that demand for single-family homes will remain strong, that single-family infill development should be encouraged in addition to multifamily, and that walkability and transit use are not incompatible with single-family homes, particularly if they are situated on modestly sized lots. While we are interested in the effects of what would be a major shift in development patterns across the state, we wanted to ensure that the building types of the new development were not radically different from past patterns.

Thus we assume that our regions and neighborhood types will see roughly the same mix of building types that they have seen in the past 15 years of development. We've estimated the mix building types by our 4-category geographic classification using two national data sets and a number of local data sets. The Census Building Permit Survey provides information on the permitting of (i) single-family homes (ii) 2-unit buildings, (iii) 3-unit buildings, (iv) 4-unit buildings, and (v) ≥5 unit buildings. It does not distinguish between attached and detached single-family buildings.

Table 18: Scenarios

	Infill Coastal	Infill Inland	Non-Infill Coastal	Non-Infill Inland
Single-family detached	33%	77%	62%	85%
Single-family attached & 2-4 unit	13%	7%	11%	5%
Multifamily low/midrise	50%	16%	27%	10%
Multifamily high-rise	5%	0%	0%	0%

To make the distinction between attached and detached single-family homes we used the 2014 American Community Survey Public Use Microdata Sample (PUMS) data. This provided information on the ratio of single-family attached production to all single-family production by Public Use Microdata Area (PUMA) by year. Each PUMA was analyzed to show the ratio of blocks in the PUMA that were infill, and also whether the block was in a coastal or inland county. This information was used to estimate the differences in the ratio of attached single-family home construction relative to all single-family home construction by infill v. non-infill and by coastal v. inland geographies.

There is no standard reference for the height of multifamily construction in the US or California. There are, however, only a few locations where land costs and demand are high enough to justify the construction of high-rise residential including San Diego, parts of the San Francisco Bay area, and Los Angeles. Analysis of a state-wide assessors database and conversations with developers support our hypothesis that these select areas are only in the parts of the state that we would classify as both infill and costal.[62]

To estimate the ratio of multifamily construction that was in high-rise buildings from 2000 to 2015, we used data from three sources. A parcel-level database from San Diego Association of Governments showed that 7,471 units were developed in high-rise buildings from 2000 to 2015 in San Diego County. A parcel-level database from the Metropolitan Transportation Commission, the regional planning organization for the San Francisco Bay Area, showed that 10,412 units of high-rise housing were developed in the 9-county Bay Area from 2000 to 2015. Lastly the City of Los Angeles's permitting records showed that 3,945 units of high-rise housing had been permitted from 2013 to 2016. This represents 5% of recent multifamily development in San Diego, 8% of all recent multifamily development in the Bay Area, and 20% of all recently permitted multifamily in the city of LA.

To estimate high-rise production in the City of Los Angeles during the full period of 2000 to 2015, we scaled up the permitting numbers. The market is very hot in LA at the moment and a number of very large multifamily projects are currently in the pipeline, such as the 464 unit Vermont apartment towers. Because of this we assumed that current permitting records are not reflective of LA's production from 2000 to 2015. Instead of using a factor of 3.75, we used 2.5 to account for the current hot market and resulting over-representation of high-rise development in the permitting pipeline. Adding LA's estimated production to production in the Bay Area and San Diego County yields an estimated total high rise unit production in California from 2000 to 2015 of approximately 27,746 units, or about 8.3% of the 335,292 total multifamily units produced in infill coastal areas.

Table 18 shows the unit distribution by building type by geography, based on historical data.

We used the historical patterns to project the regional variations and shifts in building types in our Target and Medium Scenarios.

To estimate the total number of units that will need to be constructed in the state of California from 2015 to 2030 we used household projections from the California Department of Finance.[63] The agency projects an increase of 1,785,558 households from 2015 to 2030. In addition to accommodating these new households we also adjusted the total required number of new units up to ensure that the statewide vacancy rate would not change. According to the 2015 American Community Survey, the vacancy rate for California was 7.8% of a total stock of 13,988,399 units. This adjustment yields a final estimate of 1,924,832 units that we assume will be constructed in California from 2015 to 2030.

CO_2 Reductions: VMT and Household Utilities

VMT Emissions Methodology

As discussed earlier, we aggregate Salon et al.'s seven neighborhood types into two categories based on average household weekday VMT: infill and non-infill. Salon et al.'s VMT for each neighborhood and our categorization is illustrated below.

Using our two-category aggregation, we apply a weighted average based on the number of Census tracts in each category to determine the average weekday VMT for infill and non-infill households. Each infill household will drive about 18 miles less per weekday than a non-infill household.

Table 19: Salon et al. Neighborhood Type Summary

	Number of Census Tracts	Mean Weekday Household VMT	Infill/Non-Infill
Suburb, Single Family Housing	13,017	59.66	Non-Infill
Rural	4,529	50.27	Non-Infill
Urban, Low Transit Use	13,391	41.70	Infill
Rural-in-Urban	2,320	41.09	Infill
Suburb, Multifamily Housing	14,083	40.99	Infill
Urban, High Transit Use	4,814	26,80	Infill
Central City	821	17.45	Infill

Source: Authors' analysis after Salon et al. 2014

Table 20: VMT Differences of Infill and Non-Infill

	Weighted Average Weekday VMT	Difference in VMT
Infill	38.79 miles	-18.33 miles
Non-Infill	57.24 miles	

Table 21: Analytical Assumptions for Conversions

Year	Total CO2 Emissions Factor in kg/mile	Total Population	Total VMT	Total CO2 Emissions (Metric Tons)
Suburb, Single Family Housing	0.336696	15,006,249	533,957,728	179,781

Source: California Air Resources Board EMFAC 2014 web database

Table 22: Medium and Target Scenario Differences

	Maximum Annual VMT Reduction over Baseline Scenario	Maximum Annual Greenhouse Gas (GHG) Reduction from VMT Savings over Baseline Scenario
Medium	2,385,161,826 miles	0.80 MM tons

As discussed in our definition of infill, we also categorize Census tracts with centroids within three miles of regular intra- and inter-city rail service as infill locations. Our Medium and Target Scenarios assume significant improvements to transportation infrastructure to facilitate non-personal vehicle trips to rail stations while our Baseline Scenario assumes lower rail use and a higher rate of personal vehicle trips and cold starts to access rail stations. As a result, the high-rail service tracts are only classified as infill in our Medium and Target Scenarios and not in our Baseline Scenario. This is because we assume that the additional transit investments and densification necessary to make these areas true infill areas will not occur in the absence of major policy changes.

To convert these VMT reductions to reductions in CO2 emissions, we use the California Air Resources Board's (ARB) EMFAC 2014 web database.[64] The EMFAC database is an emissions model for on-road vehicles in California. For our analysis, we use the 2016 annual statewide emissions for light-duty automobiles and light-duty trucks across aggregated model years, speeds, and fuel types. These selections provide the results in Table 21.

This emissions factor reflects the current fleet and overall fuel efficiency of personal vehicles in California today. While we expect fuel efficiency to improve over time due to technological advances, we apply the 2016 emissions factor across our projections and thus may overestimate future vehicle emissions.

We apply this emissions factor to our VMT reduction estimates to determine the greenhouse gas savings of shifting more homes to infill or lower VMT locations.

This may be a conservative estimate of the difference in the average household VMT between infill and non-infill locations. Neighborhood densification and urbanization will make our infill areas denser in 2030 than they were in the early 2000s, when Salon et al.'s data was collected. This process will also shift some tracts in lower VMT neighborhood types than their current classification. We additionally did not capture any changes in household VMT for weekend travel, which could exhibit further VMT savings for infill households.

Household Utility Emissions Methodology

Electricity

Using the estimated utilities cost data (discussed in more detail below), known electricity usage costs, and utility emission factors, we determine the associated emissions with household electricity usage. The U.S. Energy Information Administration (EIA) regularly reports on utility usage costs. In July 2016, the most recent data available, the EIA reports the average price of electricity to residential customers in California as $0.1849/kilowatt hour.[65] We apply this factor to determine household electricity usage in each of our four geographies.

Serving approximately 16 million people, Pacific Gas & Electric Company (PG&E) is one of California's two largest utility providers, along with Southern California Edison Company. PG&E regularly publishes greenhouse gas emission factors for both electricity and natural gas. The most recent electricity emissions factor is for 2013. We use PG&E's 2009-2013 historical emissions average of .2074 metric tons CO2/MWh to calculate household CO2 emissions per year from electricity.

Using the estimated utilities cost data (discussed in more detail below), known electricity usage costs, and utility emission factors, we determine the associated emissions with household electricity usage.

The U.S. Energy Information Administration (EIA) regularly reports on utility usage costs. In July 2016, the most recent data available, the EIA reports the average price of electricity to residential customers in California as $0.1849/kilowatt hour. We apply this factor to determine household electricity usage in each of our four geographies.

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Gas

We employ a similar approach to determine household CO2 emissions per year from gas. For July 2016, the EIA reports the average price of natural gas to residential customers in California as $11.97/thousand cubic feet of natural gas.[68] While some residential piped gas is not natural gas, natural gas includes 94.9% of all of California's residential piped gas.[69] We use the natural gas usage and emissions factor to calculate total residential gas emissions.

Table 23: VMT Differences of Infill and Non-Infill

	Household kWh/ Month	Household CO_2 Tons/Year from Electricity
Coastal Infill	516.47	1.29
Inland Infill	729.31	1.82
Coastal Non-Infill	508.51	1.27
Inland Non-Infill	709.44	1.77

Source: Authors' categorization of CPUC data

Table 24: Average Household Natural Gas Use by Location

	Household Therms/ Month	Household CO_2 Tons/Year from Gas
Coastal Infill	29.45	1.88
Inland Infill	31.60	2.01
Coastal Non-Infill	31.40	2.00
Inland Non-Infill	31.33	2.00

Source: Authors' categorization of CPUC data

We then apply PG&E's natural gas emission factor of .00531 metric tons CO2/therm to produce household CO2 emissions per year from gas.[70] PG&E reports a single emission factor for natural gas for all years due to the unchanging composition of PG&E's natural gas.[71]

Construction Costs

We base our estimates of the construction costs of residential development in our scenarios on data provided by the RS Means Company. RS Means conducts regular surveys of developers and aggregates and cleans the data to produce widely used data on construction. Our analysis uses two data products that describe (i) the per-square foot construction costs for various building types and (ii) regional variations in these costs. While these data are not flawless in predicting costs, they are generally accepted and are supported by other data sources on construction costs.[72]

Our scenarios provide the number of units we expect will be constructed in different areas of the state and also describes the building types of these units. In order to estimate construction costs using the RS Means data we (i) estimated the average size of units by building type, (ii) estimated building efficiencies for multifamily, and (iii) estimated the ratio of construction costs that were hard costs and architecture fees (the costs provided by RS Means) with the total construction costs (including soft costs such as insurance, financing costs, marketing, etc.).

We use an efficiency factor of 80% for multifamily construction and assume that architecture fees and hard costs account for about 60% of total construction costs, excluding land.

While the Census Bureau's Survey of Construction provides estimates of the average size of newly constructed units for the western region of the US, the underlying data are not robust enough to provide a reasonable measure of construction in California. California is, in general, a much higher cost market than the other states in the western region (which comprises all states west from Montana to New Mexico). The latest data show average new single-family detached homes of nearly 2,750 square feet, and multifamily apartments of over 1,000. Furthermore, relatively low rates of household formation and historically tight credit standards may be inflating the size of homes above what might be expected in the future. Instead of using the Census figures for the entire western region of the US we use estimates of average home sizes that have been used by scholars conducting similar analyses, particular in the state of California.[73] We assume that single-family homes will be 2,000 square feet and that multifamily apartments will be 800 net square feet, on average. The table below describes our assumptions for our construction cost analysis.

Table 25: Unit and Cost Assumptions

	Average Size (nsf)	Average Size (gsf)
Units in Single-Family Detached Structures	2,000	2,000
Units in Single-Family Attached Structures & 2-4s	2,000	2,000
Units in 5+ Unit Multi-Family Low-Rise Structures	800	1,000
Units in 5+ Unit Multi-Family High-Rise Structures	800	1,000
Efficiency Factor	80%	
Gross up to total construction cost	167%	

Table 26: RS Means per-Square Foot Cost Estimates

	Cost
1.5 Story Residential Average 2,000 sq ft wood siding wood frame	$102.25
2 Story Residential Average 2,000 sq ft wood siding wood frame Attached, assume sets of 8 rowhouses	$97.08
4-7 Story Apartment 60,000 sq ft, Decorative concrete block with reinforced concrete frame	$172.10
8-24 story apartment, 145,000 sq ft, stucco on concrete block, reinforced concrete frame	$206.35

With model units assumed we can convert unit count by building type by scenario into total square footage by building type. We can then consult the RS Means per-square foot cost data, which varies by the size of the modeled building.

RS Means also provides data on regional cost variations. These estimates define regions by clusters of zip codes and estimate the cost factor for each region relative to the standard per-square foot cost national estimates shown above. Unfortunately the RS Means data are not detailed enough to provide the precision to distinguish between infill and non-infill areas. Figure 9 shows the regional estimates in the state of California for 2015. The coverage is not complete because relatively unpopulated areas of the state are often not part of the Census's Zip Code Tabulation Areas. Generally construction costs are fairly close to the national average in the southern part of the state, and up to 25% above average in the northern part of the state, with the highest values in the San Francisco Bay area.

In order to capture these regional cost variations we divide the state into a northern and southern region for this analysis in addition to our coastal and inland division. The map below shows the north-south distinction used for the construction cost analysis.

We use a weighted average of the past 16 years of housing production to estimate aggregate cost factors for our analysis, as shown in Table 27.

Table 27: Cost Factors by Location

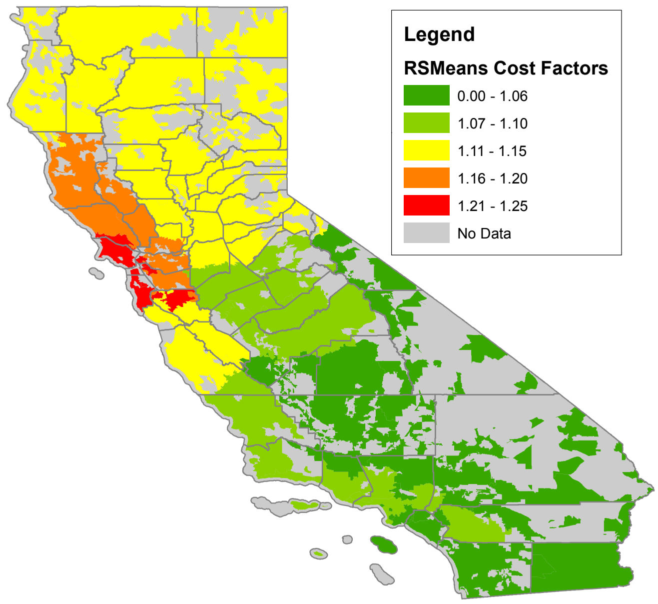
	RS Means Factors
North Coastal Infill	1.20
North Coastal Non-Infill	1.17
North Inland Infill	1.12
North Inland Non-infill	1.12
South Coastal Infill	1.06
South Coastal Non-Infill	1.05
South Inland Infill	1.03
South Inland Non-infill	1.03

Source: Authors' analysis after RSMeans

Combining these data with our housing unit assumptions by location and building type, our per-square foot estimates from RS Means, and the factors above we can estimate a per-unit cost by region and building type, shown in Table 28. As expected multifamily high-rise units are the most expensive on a per-unit basis, while low- and mid-rise multifamily are the most economical. While the RS Means data is too coarse to capture any significant cost differences between infill and non-infill areas, there is a clear, if slight, savings for inland construction, and a very large savings for construction in the southern part of the state.

We then multiplied these per-unit cost estimates with our scenario unit counts by building type and geography to estimate the total residential construction cost to accommodate 15 years of projected growth in California.

Figure 9: RS Means Zip Code Group Cost Factors



Source: Authors' analysis of RSMeans

Figure 10: North-South Distinction

Source: Authors' analysis of RSMeans

Table 28: Per Unit Costs by Building Type and Geography

	North Infill Coastal	North Infill Inland	North Non-infill Coastal	North Non-Infill Inland	South Infill Coastal	South Infill Inland	South Non-Infill Coastal	South Non-Infill Inland
Single-Family Detached Structures	409,276	381,949	399,034	383,396	360,884	349,936	357,893	351,712
Single-Family Attached Structures & 2-4s	388,577	362,632	378,853	364,006	342,633	332,238	339,793	333,924
5+ Unit Multi-Family Low-Rise Structures	344,432	321,435	335,813	322,653	303,707	294,494	301,190	295,988
5+ Unit Multi-Family High-Rise Structures	412,979	385,404	402,644	386,865	364,149	353,102	361,131	354,893

Economic Effects: Jobs, Income, & Growth

We estimated the statewide economic effects of our scenarios using IMPLAN, a software package that conducts input-output analyses to estimate economic impacts. IMPLAN is designed to model the effects of major economic changes on regions of the US. Because it cannot capture the relatively small geographic scales of infill versus non-infill development nor the distinction between single-family detached home construction and single family attached construction nor the difference between multifamily low- and mid-rise and high-rise, the differences between the scenarios arise only from (i) the regional shifts in construction from north to south and from inland to coastal California, and (ii) the shifts of building types from single-family to multifamily.

Our IMPLAN inputs were the total annualized estimated construction costs, shown in Table 29.

IMPLAN uses county-level economic data to model the annual effect of the construction volumes above on the state and regional economies. We were particularly interested in four variables: (i) the total number of new jobs produced, (ii) the total wage income of these new jobs, (iii) the total economic growth that would result from the residential construction levels described above, and (iv) the total estimated state and local tax revenue generated. Input-output analyses like those conducted in IMPLAN provide estimates of not only the direct effects of economic investments like new residential construction, such as the construction jobs and wages paid to construction workers, but also of indirect and induced economic effects. Indirect economic effects include modeling the economic activities that are necessary to support the direct effects captured in the inputs above, such as the wages paid to the California firms that produce the raw materials necessary for residential construction. Induced effects show the impact of the increases in spending that result from the growth derived from direct and indirect effects, for example the increased buying of retail goods from the construction workers and employees of California-based drywall manufacturers.

Table 29: IMPLAN Inputs

Baseline	North Coastal	North Inland	South Coastal	South Inland
Single-family	$5,510,694,826	$10,115,038,003	$8,329,538,122	$9,840,445,243
Multifamily	$3,256,921,419	$1,165,246,750	$5,997,960,260	$1,146,954,163
Medium				
Single-family	$4,967,873,355	$8,364,151,463	$9,023,554,756	$8,329,108,451
Multifamily	$3,930,607,710	$1,126,150,405	$8,054,576,859	$1,133,811,988
Target				
Single-family	$4,425,051,884	$6,613,264,922	$9,717,571,389	$6,817,771,658
Multifamily	$4,604,294,001	$1,087,054,061	$10,111,193,458	$1,120,669,814

Fiscal Impacts

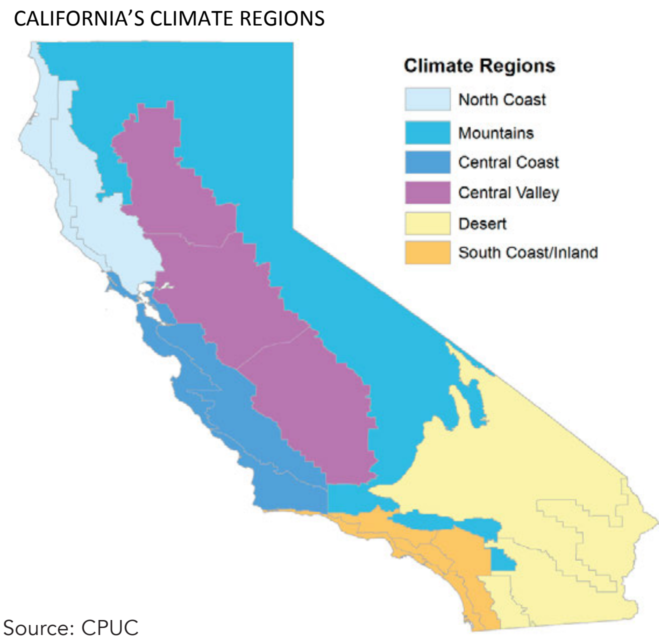
IMPLAN also provides estimates of the state and local tax revenue generated by the scenarios. We have summarized the estimates produced by the IMPLAN analysis described in the Economic Impact section above.

Household Utility Costs

The California Public Utilities Commission's (CPUC) 2015 Comparative Analysis of Utility Prices & Rates in California provides us with average monthly electric and gas bills for each of six regional climate zones: central coast, central valley, desert, mountains, north coast, and south coast/inland.[74]

Using CPUC's report and map as our guide, we classify each California county into one of CPUC's six climate zones. This classification process is imperfect as some counties straddle more than one climate zone. Our classification by county is shown in Table 30.

Figure 11: CPUC Climate Regions



Source: CPUC

Table 30: CPUC Climate Regions by County

Climate Region	Counties
Central Coast	Alameda, Contra Costa, Marin, Monterey, San Benito, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz
Central Valley	Amador, Butte, Calaveras, Colusa, Fresno, Glenn, Kern, Kings, Madera, Mariposa, Merced, Sacramento, San Joaquin, Shasta, Solano, Stanislaus, Sutter, Tehama, Tulare, Yolo, Yuba
Desert	Imperial, Riverside, San Bernardino
Mountains	Alpine, El Dorado, Inyo, Lassen, Modoc, Mono, Nevada, Placer, Plumas, Sierra, Siskiyou, Trinity, Tuolumne
North Coast	Del Norte, Humboldt, Lake, Mendocino, Napa, Sonoma
South Coast/Inland	Los Angeles, Orange, San Diego, Ventura

Source: Author's categorization of CPUC

Table 31: CPUC Average Costs by Climate Region

	Summer Electric	Winter Electric	Average Monthly Electric Bill	Summer Gas	Winter Gas	Average Monthly Gas Bill
Central Coast	$76	$86	$81.00	$24	$57	$40.50
Central Valley	$172	$102	$137.00	$15	$63	$39.00
Desert	$172	$97	$134.50	$17	$50	$33.50
Mountains	$118	$93	$105.50	$22	$47	$34.50
North Coast	$101	$100	$100.50	$19	$69	$44.00
South Coast/Inland	$113	$88	$100.50	$25	$38	$31.50

Source: CPUC

Table 32: Average Household Energy Use by Location

	Monthly Household Electric Bill	Monthly Household Gas Bill	Total Monthly Utilities Bill
Coastal Infill	$95.50	$34.16	$129.65
Inland Infill	$134.85	$36.65	$171.50
Coastal Non-Infill	$94.02	$36.42	$130.45
Inland Non-Infill	$131.18	$36.34	$167.51

Source: Authors' categorization of CPUC

We average CPUC's seasonal electricity and gas bills to get one average monthly household bill each for electricity and gas.

We then create a weighted average at the county-level based on historical housing production to determine the monthly household utility bill for each of our four geographies.

We then apply the monthly utility bill by geography to our projected unit counts to estimate the total utility costs for our three scenarios.

Household Transportation Costs

Our monthly household transportation cost estimates come from the Center for Neighborhood Technology's Housing and Transportation Affordability Index (H+T Index).[75] The H+T Index combines neighborhood and household characteristics to come up with transportation costs for households down to the neighborhood level. Household transportation costs include costs associated with auto ownership, auto usage, and public transit usage.

We use H+T Index's Annual Transportation Cost for the Regional Typical Household dataset at the place-level geography. Data is not available for places in the following counties: Alpine, Amador, Calaveras, Colusa, Glenn, Inyo, Mariposa, Modoc, Mono, Plumas, Sierra, Siskiyou, and Trinity.

For each of the remaining counties, we derive estimated transportation costs for the unincorporated area of the county. We calculate the total transportation cost for each county by multiplying the county-level household transportation cost from the H+T Index by the total of the past 16 years of housing production countywide. We then subtract the weighted total transportation costs of each jurisdiction within that county to come up with a total transportation cost for the entire unincorporated area of that county. We divide this by the unincorporated area's historical housing production to come up with a per-household number for these areas as well.

We employ a similar weighted average to that used elsewhere in this analysis to estimate household transportation costs for each of our four location types, based on historical housing production:

Table 33: Average Household Transportation Costs

	Monthly Household Transportation Costs
Coastal Infill	$1,024
Inland Infill	$1,104
Coastal Non-Infill	$1,145
Inland Non-Infill	$1,173

Our weights are adjusted to omit the counties and places within that are missing household transportation cost data.

We then multiply these household cost estimates with our simulated unit counts by geography in our scenarios to estimate the total household transportation costs for our Baseline, Medium, and Target Scenarios.

Housing Costs

To calculate the relative home prices and rents for each of our four geographies, we employ Zillow's Median Home Value Per Sq. Ft and Zillow's Median Rent List Price Per Sq. Ft for Multifamily 5+ Units at the city-level geography.[76] It is important to note that both of these datasets reflect the average home of that type available in a given location. The average home in one place will vary from the average home in another location. Our proposed housing units are only new construction and do not vary by location. New construction generally sells and rents at a premium over existing stock, so our housing cost estimates may underestimate the costs of buying or renting a new unit. By using Zillow's per square foot cost estimates, we are able to control for housing costs relative to unit size, but we do not control for unit quality, amenities, or other unit variations.

Zillow home price data is available for 439 California places. For each of these places, we calculate the average of the median home prices from January 2000 through August 2016. If data is not available beginning in January 2000, our average begins at the earliest available time after that date. This average is our home price per square foot.

We similarly calculate an average rent price per square foot. Rental data is available for 113 California places. Zillow's rent time series begins in February 2010, so our averages include February 2010 through August 2016. Again, if data for a given place is not available beginning in February 2010, our average begins at the earliest available time after that data. This average is our rent price per square foot.

We then determine the weighted average purchase and rent price for each of our four development areas, based on housing production over the past 16 years. We normalize those prices relative to the prices in low-cost non-infill locations. Our calculations omit those places without data. The results are shown in Table 34.

To calculate these costs across our scenarios, we apply these prices to our simulated units by geography. We assume that single-family homes will be 2,000 square feet and that multifamily apartments will be 800 net square feet, on average.

We estimate two separate housing cost numbers – one for average home price and one for average monthly rent. For our average home price, we assume that all of our simulated units are for sale, regardless of the building type and unit size. We then replicate this process assuming all units are for rent.

While we are shifting many units in both our Medium and Target Scenarios out of inland locations, which are generally lower cost locations than coastal areas, this increase in cost is almost completely washed out when considered per unit by the simultaneous shift to a much larger share of smaller units.

Table 34: Average Household Home Costs

	Home Price per Sq Ft	Normalized Home Price	Rent Price per Sq Ft	Normalized Rent Price
Coastal Infill	$331	X2.29	$2.30	X2.02
Inland Infill	$143	X0.99	$1.08	X0.95
Coastal Non-Infill	$290	X2.00	$2.03	X1.79
Inland Non-Infill	$144	-	$1.14	-

Source: Authors' analysis of Zillow data

Table 35: Total Sales Price and Monthly Rent by Scenario

	Baseline	Medium	Target
Total Cost if All New Units for Sale	$707,428,115,498	$720,731,224,703	$734,034,333,908
Total Cost if All New Units for Rent	$5,131,815,738	$5,166,602,009	$5,201,388,279

Source: Authors' analysis of Zillow data

Table 36: Average Sales Price and Monthly Rent by Scenario

	Baseline	Medium	Target
Average Home Price	$367,527	$374,439	$381,350
Average Monthly Rent	$2,666	$2,684	$2,702

Source: Authors' analysis of Zillow data

ENDNOTES

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17. The CBIA study asserted that adopting an 80 percent reduction goal for 2050 in statute would create a de facto mandate that all new residential construction in the state have a minimum standard of "zero net energy" (typically abbreviated as "ZNE" and defined as a building in which the amount of energy provided by on-site renewable energy sources is at least equal to the amount of energy used on site). The CBIA study authors arrived at this conclusion by asserting that SB 32 would allow opponents of new housing projects to argue, as part of the CEQA process of environmental review, that all projects must adhere to the 2050 greenhouse gas reduction goal. The study authors then argued that the first step to achieving the goal would be to build all new residential development to "zero net energy" standards. The result would be the construction of fewer housing units in the short run and higher housing costs for consumers. *See* California Energy Commission, "Energy Commission Continues March Toward Zero Net Energy With 2016 Building Energy Efficiency Standards" (Sacramento, CA, June 10, 2015), http://www.energy.ca.gov/releases/2015_releases/2015-06-10_building_standards_nr.html.

The CBIA study, however, blurred the relationship between SB 32, CEQA and the zero net energy policy, leading to flawed conclusions. First, the CBIA study's claim that project opponents could argue, through the CEQA process, that projects must comply with statewide statutory emissions targets is not supported by subsequent case law. In Center for Biological Diversity et al., v California Department of Fish and Wildlife and Newhall Land and Farming Company, 62 Cal.4th 204, 195 Cal.Rptr.3d, 361 P.3d 342 (2016) (commonly abbreviated as "Newhall"), the California Supreme Court acknowledged, "[g]iven the reality of growth, some greenhouse gas emissions from new housing and commercial developments are inevitable." The court ruled that neither AB 32 (predecessor to SB 32) nor the scoping plan adopted in conjunction with it requires lead agencies to impose statewide greenhouse gas reduction goals on individual projects. Furthermore, the law does not require lead agencies to use those statewide goals as a threshold of significance when evaluating projects pursuant to CEQA. See Center for Biological Diversity et al., v California Department of Fish and Wildlife and Newhall Land and Farming Company, 195 Cal.Rptr.3d 247 (n.d.).

Second, the CBIA study overestimated the impact of SB 32 on the state's already-launched efforts to adopt zero net energy standards for new residential and commercial construction. In short, California was planning to achieve the ZNE standard for new construction with or without SB 32. As mentioned, a zero-net energy building consumes only as much energy on an annual basis as can be generated with an on-site renewable energy system. California has been steadily progressing toward robust energy efficiency for several decades, and the state set a ZNE goal almost a decade ago, based on existing statutory authority. The California Energy Commission's "2007 Integrated Energy Policy Report" (IEPR) established the goal for all residences by 2020 and for commercial buildings by 2030.

In contrast to the CBIA's claim of a sudden, across-the-board zero net energy mandate, the California Energy Commission has developed a tiered approach to achieving zero net energy using building energy efficiency standards, with standards becoming more stringent in every three-year code cycle. The Energy Commission employed an innovative approach of increasing mandatory energy efficiency standards within the energy code (Cal. Code Regs. tit. 24, part 6) while encouraging local jurisdictions to use higher level "reach" voluntary standards available through the California Green Building Standards Code (CAL Green) from the state's Building Standards Commission. The California Building Industry Association (CBIA) endorsed the 2016 Title 24 Standards, which tightened energy efficiency requirements for heating, cooling and lighting. The California Energy Commission is working with investor-owned and municipal utilities, the building industry, equipment manufacturers, and other stakeholders on the development of the 2019 Title 24 update.

Notably, the 2013 Energy Code was intended to reach 70 percent of the residential ZNE goal; the 2016 Energy Code 85 percent, and the 2019 Energy Code will meet the goal of ZNE. The 2016 standards, which will take effect January 1, 2017, updated residential heating, air and lighting requirements to move closer to the 2020 goal. *See* The Warren-Alquist Act, enacted in 1976, mandated that the California Energy Commission develop and periodically update Building Energy Efficiency Standards for the state of California. See California Energy Commission, "Warren-Alquist Act," accessed October 16, 2016, http://www.energy.ca.gov/reports/Warren-Alquist_Act/.. These Standards, first adopted in 1977 and enshrined in Title 24 of the California Code of Regulations, address newly constructed buildings and additions and alterations to existing buildings. The standards have, in combination with appliance efficiency standards and utility-sponsored incentive programs, strongly contributed to California's relatively flat per capita electricity consumption levels since the mid-1970s. The standards are updated on an approximately three-year cycle. See also California Energy Commission, "2007 Integrated Energy Policy Report (Adopted December 5, 2007)," accessed October 16, 2016, http://www.energy.ca.gov/2007_energypolicy/index.html.

The 2010 CALGreen incorporates three levels of energy efficiency: a basic level fixed to the energy code as well as two options: Tier 1 at 15 percent increase above Title 24, and Tier 2 at 30 percent increase above Title 24 requirements. Local jurisdictions have the ability to adopt and enforce local Tier 1 and Tier 2 ordinances (or reach codes) based on specific state guidelines and requiring approval from the Energy Commission and filing with the Building Standards Commission. The state also links CALGreen and the Energy Code updates so that all are on the same path traveling at the same speed. *See* California Energy Commission, "Energy Commission Continues March Toward Zero Net Energy With 2016 Building Energy Efficiency Standards."

Third, the CBIA report incorrectly implied that the only way new residences can meet the zero net energy goal is through mandatory installation of on-site solar panels. Yet the California Energy Commission, as it develops the 2019 regulations, will be considering other options, such as higher levels of energy efficiency in dwelling units to reduce the need for large solar arrays. The commission may also determine that for some developments, such as multifamily units, community-scale solar may be preferable to installing solar panels on every new residential unit to meet the 2020 ZNE goal. In addition, the commission will evaluate "grid harmonization" strategies that will maximize self-utilization of the array's output and minimize the exports to the grid; these measures include but are not limited to electric vehicle charging stations, enhancing thermal and electric storage, demand response, and load shifting strategies. The California Energy Commission also conducts separate analyses for each individual climate zone around the state, which may lead to differing requirements for various zones.

Finally, the estimated costs of energy-related equipment and installation cited in the CBIA study exceed industry standards, including gross overestimations of rooftop solar panel prices, even based on current numbers. As is the case with all new technologies, costs will most likely continue to decline not only for the technology itself but also for the construction process as the industry gains expertise. *See* National Renewable Energy Laboratory, "The Open PV Project," accessed October 26, 2016, https://openpv.nrel.gov/; Solar Energy Industries Association, "Photovoltaic (PV) Pricing Trends: Historical, Recent, and Near-Term Projections," SEIA, accessed October 26, 2016, http://www.seia.org/research-resources/photovoltaic-pv-pricing-trends-historical-recent-near-term-projections. See also Green Technology, "Green Codes And Standards," July 8, 2016, http://green-technology.org/green-codes-and-standards/net-zero.htm.

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