Vision California: Modeling California's Future

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ABSTRACT

This paper focuses on Vision California, a new project that explores the critical role of land use and transportation investments in meeting the energy, environmental, fiscal, and public health challenges facing California. Funded by the California High Speed Rail Authority and the California Strategic Growth Council, the project is producing new scenario development and analysis tools, and a series of alternative physical visions for how California can accommodate expected growth. It will clearly express the consequences of these options in meeting critical climate and energy goals, and will enhance the technical capacity to model the collateral impacts and co-benefits of land use and investment decisions. It will illustrate the critical linkages between land use and other major challenges, including water consumption, energy use, housing affordability, public health, farmland preservation, infrastructure provision, and economic development. It will connect land use and infrastructure priorities to targets as set by Assembly Bill 32, the California Air Resources Board, and the California Energy Commission in its push towards zero-net energy targets.

The paper describes the Vision California 'Rapid Fire' modeling tool and a set of state-wide scenarios that measure the impact of varying land use patterns, transportation investments, and policy directions on greenhouse gas emissions, air pollution, water and energy use, land consumption, and infrastructure cost. It provides brief background material on the Vision California project, and summarizes the model's key features, a set of statewide scenarios, and their results. A detailed description of the Rapid Fire model can be found in the *Rapid Fire Model White Paper and Technical Guide*[1]. More information about the Vision California project can be found at cahighspeedrail.ca.gov and at www.calthorpe.com/vision-california.

Modeling Tools Overview

Vision California includes the development of two distinct yet complementary modeling tools: the 'Urban Footprint' map-based model and the Rapid Fire spreadsheet-based tool. The Urban Footprint map-based model, currently under development, uses geographic information system (GIS) technology to create and evaluate physical land use-transportation investment scenarios. Output metrics will include: land consumption; infrastructure cost (capital as well as operations & maintenance); building energy and water consumption, cost, and associated CO_2 emissions; public health impacts; vehicle miles traveled and all related fuel, GHG, and pollutant emissions; and non-auto travel mode share and other related travel metrics.

The Rapid Fire model is a user-friendly, spreadsheet-based tool that produces and evaluates high-level national, statewide and regional scenarios. The Rapid Fire model allows for efficient, iterative, and transparent testing of different combinations of growth patterns for a wide variety of metrics including VMT; greenhouse gas emissions from cars and buildings; air pollution; fuel use and cost; building energy and water use and cost; land consumption; and

[1] For copies of the *Rapid Fire White Paper and Technical Guide*, please contact Calthorpe Associates directly at: VisionCalifornia@calthorpe.com.

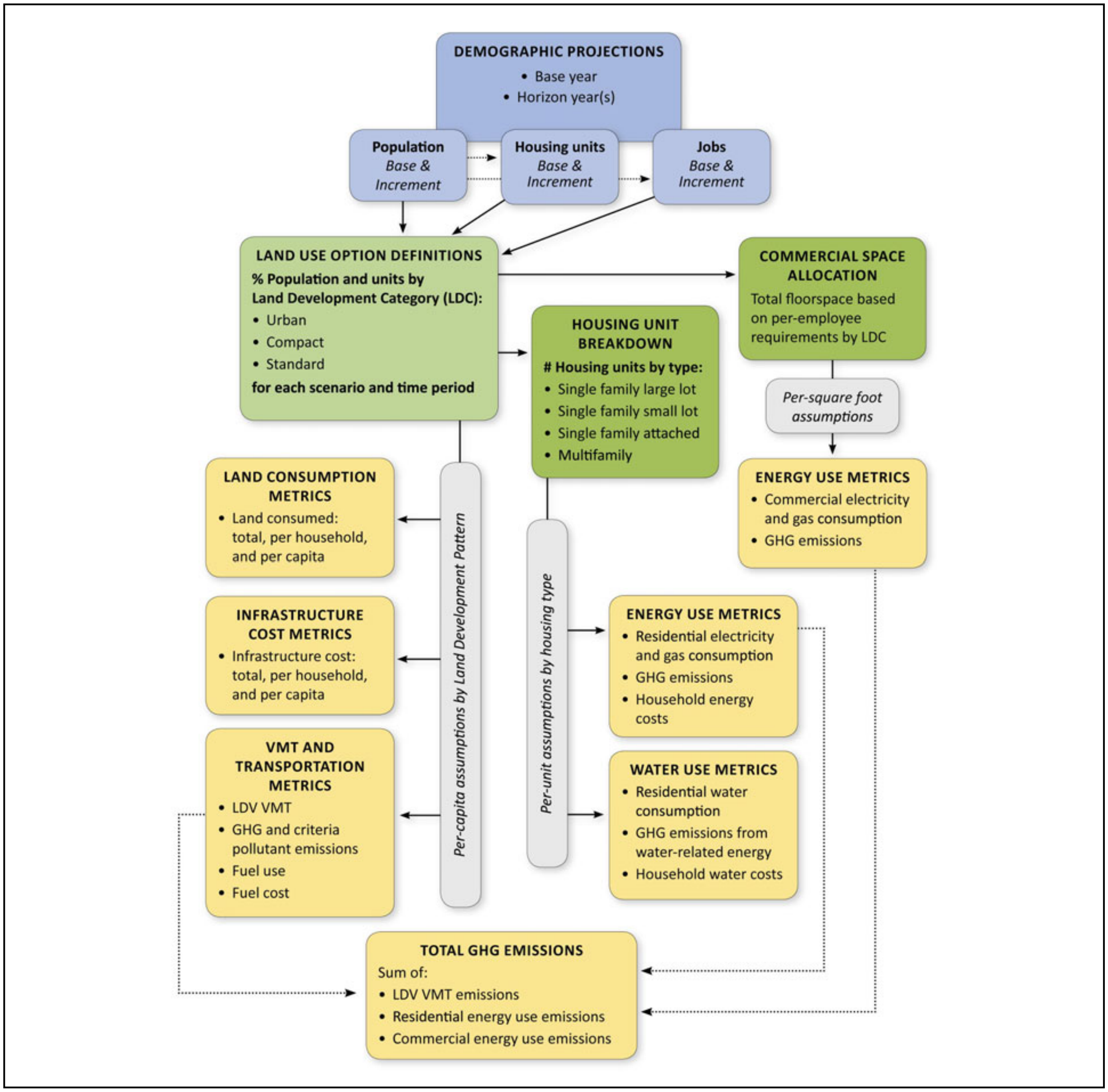
infrastructure cost. The Rapid Fire tool can run on virtually all desktop and laptop computers, and is designed so that all assumptions are clear, transparent, and can be easily modified or customized.

The Rapid Fire model emerged out of the near-term need for a comprehensive modeling tool that could inform state and regional agencies and policy makers in evaluating climate, land use, and infrastructure investment policies. The model calculates results based on empirical data and the latest research on the role of land use and transportation systems on automobile travel; emissions; and land, energy, and water consumption. It provides a single transparent framework within which these assumptions and research can be loaded to test the impacts of varying land use patterns on environmental sustainability and fiscal performance.

The Rapid Fire Model Framework

The Rapid Fire model produces results for scenarios at the national, statewide, or regional scale. Figure 1 outlines the operational flow of the model, showing generally how growth in population, housing units, and jobs are allocated, and assumptions applied, to estimate output metrics. The model's output metrics include greenhouse gas (CO_2e) emissions from cars and buildings; air pollution; fuel use and cost; building energy and water use and cost; land consumption; and infrastructure cost. Within the model, all input assumptions are clearly identified and can be easily modified. Results for all metrics are summarized such that users can easily compare the impacts of different scenarios.

Figure 1: Rapid Fire Model Flow



California Rapid Fire Scenarios

The Rapid Fire model was used to analyze a set of statewide growth scenarios. Each scenario pairs one of three distinct land use options with one of two policy packages. The land use options vary the patterns of new growth, while the policy packages vary standards for automobile technology and fuel composition, building energy and water efficiency, and energy generation. The scenarios highlight the impacts of land use on GHG emissions and other critical metrics, as well as the combined impacts of land use and policy, which are vital to discussions as California pursues its aggressive climate, energy, water, and fiscal efficiency targets.

Each scenario accommodates the same amount of projected population and job growth to the years 2020, 2035, and 2050. By 2050, the state's population is expected to grow to 59.5 million people[2] and 24 million jobs[3]. This paper compares the four distinct scenarios described below. The land use and policy components are described in greater detail on the following pages.

- **A1, Trend Growth / Trend Policy: BUSINESS AS USUAL**: This scenario combines the historic land use patterns of past decades with a very moderate set of policies for auto and fuel technology, building energy and water efficiency, and energy generation. It serves as an important comparison to other scenarios in which land use and policy trends undergo more significant change.
- **B1, Mixed Growth / Trend Policy:** This scenario tests a future in which roughly half of new growth is accommodated in compact and urban forms, and half in standard. This land use pattern is combined with the "Trend" policy set.
- **C1, Smart Growth / Trend Policy:** In this scenario, the state sees an increasing proportion of urban infill and compact growth. This land use pattern is combined with the ”Trend" policy set
- **C2, Smart Growth / Green Policy. GREEN FUTURE.** In this scenario, the state sees an increasing proportion of urban infill and compact growth. This land use pattern is combined with a "Green" policy set that reflects the relatively ambitious direction of state policies that have already been adopted, or are under consideration by the California Air Resources Board, California Energy Commission, California Public Utilities Commission, and other state agencies.

Land Use Options

The Vision California Rapid Fire scenarios include one of three distinct land use options: Trend, Mixed Growth, or Smart Growth. Each of the land use options is defined by the proportion of growth allocated to different Land Development Categories (LDCs). The LDCs represent distinct forms of land use, ranging from dense, walkable, mixed-use urban areas that are well served by transit, to lower-intensity, less walkable places where land uses are segregated and most trips are made via automobile. The three LDCs – Urban, Compact, and Standard – are described in Table 1.

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[2] Population projections from California Department of Finance.
[3] Job projections based on California Employment Development Department data, extrapolated to 2050.

Table 1: Land Development Categories

	Land Use Characteristics	Transportation Infrastructure
Urban	Often found within and directly adjacent to moderate and high density urban centers. Virtually all 'Urban' growth would be considered infill or redevelopment. Majority of housing is multifamily and attached single family (townhome), which tend to consume less water and energy than the larger types found in greater proportion in less urban locations.	Supported by high levels of regional and local transit service. Well-connected street networks and the mix and intensity of uses result in a highly walkable environment and relatively low dependence on the automobile for many trips. Per-capita VMT ranges from 1,500 to 4,000 per year.
Compact	Less intense than Urban LDC, but highly walkable with rich mix of retail, commercial, residential, and civic uses. Most likely to occur as new growth on the urban edge, or large-scale redevelopment. Rich mix of housing, from multifamily and attached single family (townhome) to small- and medium-lot single family homes. Housing types tend to consume less energy and water than the larger types found in the Standard LDC.	Well served by regional and local transit service, but may not benefit from as much service as Urban growth, and is less likely to occur around major multimodal hubs. Streets are well connected and walkable, and destinations such as schools, shopping, and entertainment areas can typically be reached via a walk, bike, transit, or short auto trip. Per-capita VMT ranges from 4,000 to 7,500 per year.
Standard	Majority of separate-use auto-oriented development of American suburban landscape over past decades. Densities tend to be lower than Compact LDC, and are generally not highly mixed or Medium- and larger-lot single family homes comprise the majority of this development form; these types tend to consume more energy and water than those in the Urban or Compact LDCs.	Standard areas are not typically well served by regional transit service and most trips are made via automobile. Per-capita VMT ranges from 9,000 to 18,000 per year.

The proportion of growth allocated to the three LDCs in each land use option results in different housing type mixes. The land use options are as follows:

- **Land Use Option A. Trend Growth**: The Trend option represents a future based on historic market trends, land use patterns, and transportation investments and behavior in California[4,5,6]. By 2050, new growth in this option is composed of 70% Standard, 25% Compact, and 5% Urban development. The resulting housing type mix aligns with historic development trends in California, in which single family detached homes have comprised the majority of new construction in major metropolitan areas.
- **Land Use Option B. Mixed Growth**: This option reflects the least-aggressive end of projected market and development trends, which indicate that 50 to 70% of development in California between 2010 and 2020 should be Compact or Urban. These trends stem from changing demographics and lifestyles, trends in construction, the undersupply of

[4] The developed footprint has been growing at a rate of roughly 1.6% per year annually since 1980, a rate of land development that has outpaced population growth by 25% (Theobald, 2005).
[5] Caltrans estimates that VMT will continue to increase at nearly three percent per year for the foreseeable future under current trends (Bartholomy, et al., 2007).
[6] UC Davis ITS estimates that, under current trends, VMT per capita will increase to 9,975 by the year 2050 (Yang, McCollum, McCarthy, & Leighty, 2008).

compact units[7] on the market, and projected energy price increases (Ewing & Nelson, CO_2 Reductions Attributable to Smart Growth in California, 2008). Accordingly, new growth in this option is composed of 50% Standard, 40% Compact, and 10% Urban development.

- **Land Use Option C. Smart Growth**: The Smart Growth option assumes that a greater share of new growth will occur in Urban and Compact forms to meet a current and projected undersupply of compact development and align with projected demographic, regulatory, and market[8] trends. This option accommodates 55% of new growth in Compact, 35% in Urban, and 10% in Standard forms by 2050.

Policy Packages

The policy packages represent different levels of improvement in automobile and fuel technology, building energy and water efficiency, and energy generation. For comparison, a business-as-usual approach is contrasted with a more aggressive set of policies that reflects the current direction of state agencies as they address the regulatory framework required to meet climate, energy, water, and fiscal challenges. The policy package assumptions were developed in coordination with the state agencies responsible for policy development and implementation.

- **Policy Package 1. Trend Policy**: The Trend policy package assumes that California meets, but does not improve beyond, its currently adopted standards for vehicle fuel economy (Pavley I Clean Car Standard) and fuel emissions (Low Carbon Fuel Standard), and makes modest improvements in building energy and water efficiency, and the proportion of renewable resources[9] used by utilities in their power generation portfolio. These policy assumptions are an important component of any business-as-usual future and serve as a comparison to a future in which more aggressive policies are adopted and achieved.
- **Policy Package 2. Green Policy**: The Green policy package reflects the relatively aggressive direction of adopted state policies and those under consideration by the Air Resources Board (CARB), California Energy Commission (CEC), California Public Utilities Commission (CPUC), and other agencies. It includes leading-edge policies for vehicle fuel economy, the carbon intensity of fuel, building energy and water efficiency, and the proportion of renewable resources used by utilities in their power generation portfolio. This policy package, when combined with each of the three land use options, tests a future in which these aggressive policies are adopted and achieved.

[7] "Compact development" includes small-lot single family and attached housing unit types. See also discussion regarding factors driving compact growth in (Ewing, Bartholomew, Winkelman, Walters, & Chen, 2008).

[8] According to a recent article in the Sacramento Bee quoting the of SACOG Executive Director Michael McKeever, "60 percent to 70 percent of recent new housing across the region and much now in the pipeline is on 'small lots' of 5,000 square feet or less, or is attached, as in condominiums and townhouses." (Wasserman, 2009).

[9] Within the context of this paper, "renewable" refers to any utility power generation technology that does not directly produce greenhouse gases. Hydroelectric, solar, wind, wave, nuclear energy are all thus defined as renewable, while energy from natural gas, oil, and coal are not.

The core assumptions of each policy package are summarized in Table 2. Details about the policy packages and how they are adjusted in the Rapid Fire model can be found in the *Rapid Fire Model White Paper and Technical Guide*.

Table 2: Policy Package Summary

	TREND POLICY			GREEN POLICY		
	2020	**2035**	**2050**	**2020**	**2035**	**2050**
Transportation						
Fuel economy	24 mpg[10,11]	27 mpg	28 mpg	25 mpg	38 mpg	54 mpg
Buildings						
Energy use of new buildings (% below 2005)	10%	20%	30%	30%	55%	80%
Energy use of existing buildings (% less per year)	0.5%	0.5%	0.5%	0.75%	1.25%	2%
Water use of new residential buildings (% below 2005)	10%	20%	30%	30%	50%	70%
Water use of existing buildings (% below 2005)	10%	15%	20%	25%	35%	50%
Energy Emissions						
Transportation fuel emissions (lbs CO_2e/gal ge)	17.7 lbs	17.7 lbs	17.7 lbs	17.7 lbs	13.7 lbs	9.8 lbs
Electricity emissions	0.69 lbs/kWh	0.62 lbs	0.58 lbs	0.58 lbs	0.48 lbs	0.35 lbs
Natural gas emissions	11.7 lbs/therm	11.7 lbs	11.7 lbs	11.7 lbs	11.7 lbs	11.7 lbs

California Rapid Fire Scenarios Model Results

Land Consumption and Infrastructure Cost

The amount of land needed to accommodate new population growth varies substantially among the Rapid Fire scenarios. Scenarios A1, which accommodates 70% of growth through 2050 in the Standard LDC, consumes more than twice the land of Scenario C1, which accommodates from 80% to 90% of new growth in the Compact and Urban LDCs. The 'C' scenarios C1 include a very low proportion of low-density greenfield growth, focusing instead on infill and redevelopment within existing urban areas and on more compact forms of new growth.

Increased land consumption leads to higher costs for local and sub-regional infrastructure, as new greenfield development requires significant capital investments in new local roads, water and sewer systems, and dry utilities (electricity, gas, phone, and cable). Conversely, growth focused in existing urban areas takes advantage of existing infrastructure and capitalizes on the efficiencies of providing service to higher concentrations of jobs and housing.

[10] Values are rounded.
[11] Throughout paper, all fuel metrics are expressed in terms of gasoline equivalent (ge).

Comparing Scenario A1 to Scenarios C1 and C2, local and sub-regional infrastructure cost savings add up to more than $24,000 per new household by 2050 – a cumulative savings of more than $65 billion through 2020, and $194 billion through 2050.

Transportation Metrics

Transportation system impacts – including vehicle miles traveled (VMT), fuel use and cost, and GHG and air pollutant emissions – vary significantly across the Rapid Fire scenarios. The different land use options result in different rates of passenger automobile use, measured as vehicle miles traveled, or VMT[12]. The subsequent effect of VMT on fuel consumption, cost, and emissions are determined by specific policy-based assumptions about auto fuel economy and technology, and fuel composition and cost.

Vehicles miles traveled. The Rapid Fire model calculates VMT by applying assumptions about per-capita annual VMT to population growth. These assumptions, which differ by LDC, are based on research and empirical evidence[13] that *per-capita VMT of both incremental (new) population and base year (existing) population vary based on the form of new growth.* Moreover, this variation is expected to change over time as areas become either more urban or compact, or more sprawling (determined on the proportions of LDCs in a scenario).

As shown in the chart and table in Figure 2, scenario results for VMT indicate a wide variation in passenger vehicle use related to the form of new growth. Scenario A1, which accommodates 70% of growth in auto-oriented Standard development, sees much higher VMT rates than Scenarios B1 and C1/C2. Note that VMT is determined by a scenario's land use option, and is independent of the policy packages selected; C1 and C2, with the same land use option, result in identical VMT estimates.[14]

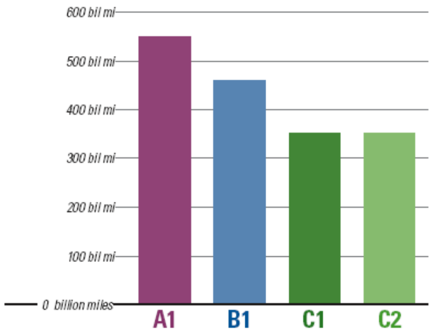
[12] Baseline 2005 California state average vehicle fuel economy and VMT per capita were calculated using the CARB Emissions Factors (EMFAC 2007) model. EMFAC vehicle classes included in the LDV fleet: light-duty automobiles (LDA), light-duty trucks up to 5750 lbs (LDT1 and LDT2), and medium-duty trucks up to 8500 lbs (MDV).

[13] Key work informing the model's VMT assumptions include *Growing Cooler* (Ewing, Bartholomew, Winkelman, Walters, & Chen, 2008); "The Case for Moderate Growth in Vehicle Miles of Travel" (Polzin, 2006); and data from John Holtzclaw (Holtzclaw, 1998; Holtzclaw, Burer, & Goldstein, 2004; Holtzclaw, Clear, Dittmar, Goldstein, & Haas, 2002). For more information about the VMT assumptions used by the Rapid Fire model, please see the *Rapid Fire Model White Paper and Technical Guide*.

[14] As noted above, the variations in VMT across the scenarios is a result of year-by-year variation in per capita VMT by form of new growth (Urban, Compact, or Standard), and also the impact of new growth on the travel behavior of those already living in California in the base year (2005). For example, if one is living in an area 20 years from now that has seen increased transit service and/or new retail development in close proximity to their home or workplace, it is likely that they will drive less (and walk, bike, or take transit more) because daily needs and services are closer.

Figure 2: Annual Passenger Vehicle Miles Traveled

Total Annual VMT



Annual VMT per Capita

	2005	2035	2050
A1 BUSINESS AS USUAL	8,100 mi	8,740 mi (+ 8%)	9,050 mi (+ 12%)
B1 TREND POLICY / MIXED GROWTH	8,100 mi	7,850 mi (- 3%)	7,850 mi (- 3%)
C1 TREND POLICY / SMART GROWTH	8,100 mi	6,670 mi (- 18%)	5,970 mi (- 26%)
C2 GREEN FUTURE	8,100 mi	6,670 mi (- 18%)	5,970 mi (- 26%)

Automobile fuel use. Variations in passenger VMT lead to substantial differences in the amount of automobile fuel (gasoline equivalent) used in each of the scenarios. When combined with policy variations for automobile efficiency and fuel cost, the scenarios illustrate the combined impact of land use and policy packages. Scenario A1, with only moderate increases in automobile efficiency, sees higher fuel use than all other scenarios. Scenarios A1, B1, and C1,which all include the same moderate fuel efficiency policies, show significant differences in fuel use due to land use-related VMT variations. Combined with more aggressive fuel efficiency policies, the smart growth land use pattern of Scenario C2 reduces annual auto fuel use by more than 66% in 2050 as compared to the trend land pattern in Scenario A1. Between 2005 and 2050, the savings amount to over 260 billion gallons of fuel – an amount equivalent to nearly four years of oil imports to the U.S.

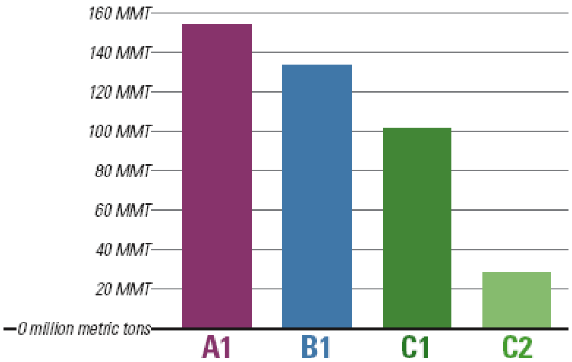
Reduced VMT and fuel use leads to lower costs for all households in California. When compared to Scenario A2, Scenario C2, with its smart land use pattern, saves the average California household more than $8,600 per year in driving-related costs (including fuel, ownership, and maintenance) in 2050 – statewide, the savings total $170 billion per year.

Greenhouse gas emissions from passenger vehicles. GHG emissions from passenger vehicles are affected by VMT (which is related to land use patterns), vehicle fuel economy, and the carbon intensity of automobile fuel. Scenarios A1, B1, and C1, with California's Pavley vehicle standards and Low Carbon Fuel Standard in place to 2020, reveal the emissions differences among land use options. Scenario C2 demonstrates the impact of adding the continued improvements of the Green policy package to a Smart Growth future..

As shown by the chart in Figure 3, Scenario C1 highlights the significant impact of land use on vehicle GHG emissions, with 2050 emissions that are 34% lower than those of Scenario A1. With its combination of more compact and urban land uses and advanced vehicle and fuel policies, GHG emissions in Scenario C2 are fully 80% lower than those of A1. The results across all scenarios highlight the need to seek further reductions though more compact land patterns and progressively stronger vehicle and fuels policies to 2050.

Figure 3: Annual Passenger Vehicle GHG Emissions (MMT CO_2e)

Total Annual GHG Emissions (MMT CO_2e)



Per Capita Annual GHG Emissions (lbs CO_2e)

	2005	2035	2050
A1 BUSINESS AS USUAL	8,500 lbs	5,720 lbs (- 33%)	5,730 lbs (- 33%)
B1 TREND POLICY / MIXED GROWTH	8,500 lbs	5,130 lbs (- 40%)	4,970 lbs (- 42%)
C1 TREND POLICY / SMART GROWTH	8,500 lbs	4,360 lbs (- 49%)	3,780 lbs (- 56%)
C2 GREEN FUTURE	8,500 lbs	2,390 lbs (- 72%)	1,080 lbs (- 87%)

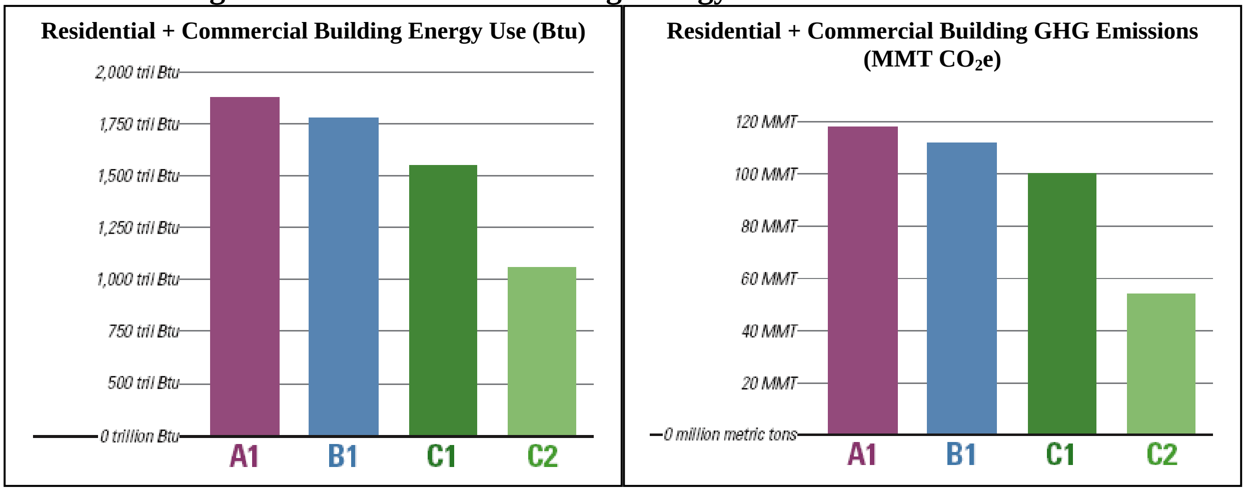
Residential and Commercial Building Energy

The Vision California Rapid Fire scenarios vary in their residential and commercial energy use profiles due to their building program and policy assumptions. Scenarios B1, C1, and C2, which include a larger proportion of Compact and Urban development, accommodate a higher proportion of growth in more energy-efficient housing types like townhomes, apartments, and smaller-lot single family homes, and more compact commercial building types. By contrast, the large proportion of Standard development in Scenario A1 leads to a higher proportion of large-lot single family housing, which is typically less energy-efficient due to their larger sizes. When combined with the effects of more stringent building efficiency and clean energy policies, how each scenario accommodates growth has a very significant impact on resource consumption, cost, and GHG emissions.

The Rapid Fire model calculates building energy use for the base/existing population (residential and commercial buildings already built by the 2005 baseline year) and for the growth increment (new buildings built during the time span of the model). To estimate energy use for base/existing buildings, the model assumes rates of building retrofits, upgrades, and replacement. For new buildings, the model assumes that, year upon year, new construction will be built to meet higher efficiency standards. The energy use reduction factors associated with the different building stock populations are intended to account for a combination of policies affecting building energy use, including improvements in building efficiency, the use of more efficient appliances, and, significantly, the use of power from on-site renewable energy systems. The energy use reductions assumed in the Trend and Green policy packages represent general policy directions; within the model, users can easily adjust or calibrate the assumptions to test the effects of implementing specific policies.

Figure 4 shows the differences in building energy use and emissions among the scenarios. Building energy use in Scenario C2, which incorporates both smart land use and Green policies, is more than 43% lower in 2050 than that in Scenario A2, which has the same policy assumptions but a more sprawling, trend-based land pattern. The cumulative cost savings to 2050 amount to more than $225 billion, or approximately $6.4 billion per year in 2035, and $15 billion in 2050. Greenhouse gas emissions generally track energy use, with the most substantial reductions seen in scenarios that combine smarter land patterns and green building and energy policies.

Figure 4: Total Annual Building Energy Use and GHG Emissions



Residential Water

The building program and policy variations among the Vision California Rapid Fire scenarios lead to considerable differences in water use and cost. Residential water use is a function of both indoor and outdoor water needs, with outdoor use (landscape irrigation) accounting for the majority of the difference among housing types. Because homes with larger yards require more water for landscape irrigation, lot size is generally correlated with a household's overall water consumption. Thus, scenarios with a greater proportion of the Standard Land Development Category, which includes primarily large-lot single-family homes, require more water than scenarios with a greater proportion of Compact or Urban areas, which include more attached and multifamily homes. Higher water use also leads to higher GHG emissions resulting from the energy needed to treat and distribute water.

Residential water use in Scenario C1, with smart land use and trend-based policies, is almost 10% lower in 2050 than that of Scenario A1, with its more dispersed land pattern. Residential water use in Scenario C2, with both smart land use and Green policies, is over 40% lower than that of A1. The difference in cumulative water use between A1 and C2 amounts to nearly 78 million acre feet by 2050 – enough water to fill California's Hetch Hetchy Reservoir over 200 times. The average household uses 40,000 gallons less per year by 2035, and 55,000 gallons less per year by 2050. Cumulative consumer cost savings to 2050 amount to more than $96 billion. Total water use in Scenario C2 costs $2.5 billion less per year in 2035, and $5 billion less in 2050.

Water-related GHG emissions result from two main energy use categories: a) *water system uses*, including the transport and treatment of water consumed; and b) *water end uses*, including all uses of water that occur within homes (e.g., water heating)[15]. The Rapid Fire model calculates energy use and emissions for system uses, while emissions resulting from end uses are accounted for as a component of residential and commercial building energy emissions. Water-related GHG emissions vary across the Vision California Rapid Fire scenarios with changes in water energy use and the rate of GHG emissions from electricity. Total emissions for Scenario

[15] In California, 19% of all electricity and 30 percent of natural gas are associated with urban and agricultural water use; of this, 73% of the electricity and nearly all of the natural gas are associated with end uses. These energy uses are estimated to account for at least 44 MMT CO2 average annual emissions. (DWR 2009, CEC 2007).

C1 are 10% lower than A1 in 2050; with the Green policy package of Scenario C2, the difference grows to 64%. Scenarios A1 and C1 have the same policy set and thus highlight the impact of land use patterns and building program on this component of GHG emissions.

Total Greenhouse Gas Emissions & Costs

Combined transportation and building sector impacts provide the most complete picture of the greenhouse gas emissions and fiscal implications of the futures presented by the Vision California Rapid Fire scenarios. Passenger vehicle transportation, along with residential and commercial building energy use, currently account for over half of total carbon emissions in California. Emissions and costs vary significantly across the four scenarios, highlighting the importance of both land use patterns and policies regulating energy emissions and efficiency on California's greenhouse gas emission reductions goals and financial health.

GHG emissions from transportation and buildings. Total GHG emissions – including those from passenger vehicles, and emissions associated with residential and commercial building energy consumption – vary greatly across scenarios due to differences in land use and policy. Scenario A1, with its business-as-usual land use pattern and policy set, sees the highest total GHGs from both buildings and transportation through all horizon years. Scenarios B1 and C1, with the same Trend policy set, highlight the impact of land use patterns in total greenhouse gas emissions from buildings and transportation. Scenario C1, with its more efficient land use pattern, produces significantly fewer GHG emissions than A1 or B1. Scenario C2, which combines the efficient land use pattern with Green policies, is able to further reduce total GHG emissions.

Figure 5 summarizes how land use and specific Green policy options contribute to GHG emission savings in California by 2050. The bottom set of bars represents emissions from passenger vehicle transportation, while the top set represents emissions from residential and commercial energy use. Moving from left to right, each column applies one additional land use change or policy based on the scenario options outlined in this report. Overall, the results make it evident that meeting AB 32's goal of reducing GHG emissions to 80% below 1990 requires comprehensive and progressive land use action, as well as policy moves across multiple sectors and agencies throughout the state. This chart highlights the challenges of meeting this goal, with smart growth and policy options combining to help the transportation sector nearly meet the 80% reduction target, but leaving building emissions at still more than twice AB 32's 2050 target.

Total costs. The total cost burden for the four Vision California Rapid Fire scenarios varies along with the resource consumption of each of the scenarios. Infrastructure capital costs, as well as household transportation, energy, and water costs, are much higher in scenarios with more land consumption, higher VMT, and building programs that rely more on larger lot single family construction. Thus, scenarios A1 exhibits higher total costs than the other scenarios. Comparing the three scenarios with the same Trend policy set isolates the impact of land use on total cost: Scenario C1, with the lowest land consumption and VMT, and the most resource-efficient building program, saves more than $1 trillion by 2035 over Scenario A1, and more than $2.6 trillion by 2050. Table 3 breaks down costs to the household level and highlights the impact of land use and policy choices on California households.

Figure 5: GHG Emissions from Transportation and Building Energy (MMT CO_2e)

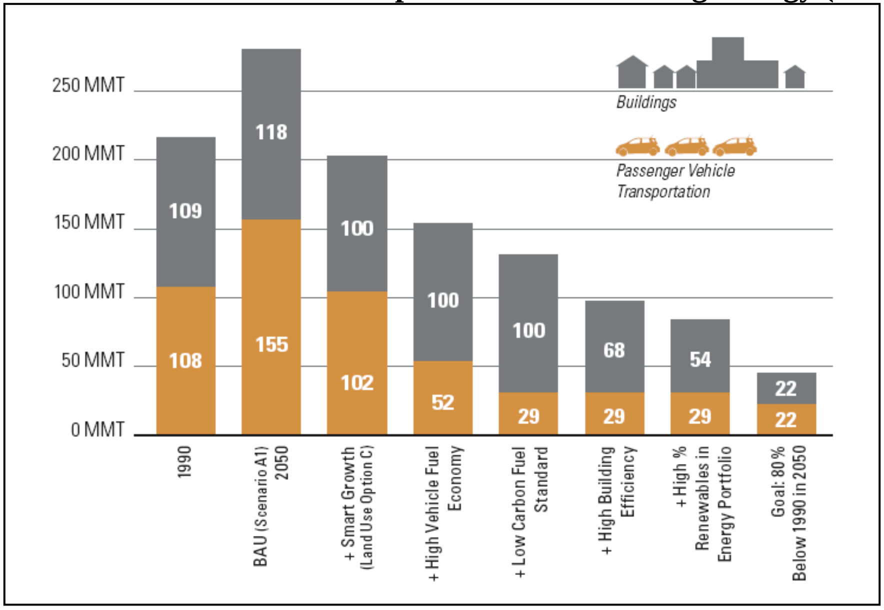


Table 3: Average Annual Household Expenditures:
Fuel and Auto Costs, Residential Electricity, Gas, and Water (2008 dollars)

Scenario	2035	2050
A1. Business as Usual	$17,100	$20,750
B1. Trend Policy / Mixed Growth	$15,550	$18,300
C1. Trend Policy / Smart Growth	$13,450	$14,350
C2. Green Future	$12,000	$11,150

Conclusion

The Vision California project and the scenarios presented in this paper are intended to inform more sustainable policy development and infrastructure programming in California. The Rapid Fire modeling tool can help local, regional, and state agencies more fully understand how land use and future growth decisions impact energy, water, climate, public health, and fiscal performance. As California continues down the path towards meeting the bold GHG reduction targets set by AB 32, and the energy and water resource targets of the CEC, other state agencies, and leading-edge municipalities, Vision California and its analytical and scenario development tools will help decision makers, stakeholders, and the public understand the impacts of policy and investment decisions.

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