VISION CALIFORNIA | *CHARTING OUR FUTURE*

STATEWIDE SCENARIOS REPORT

California must plan for future growth – by 2050, the state's population is expected to grow to nearly 60 million people and 24 million jobs. The path that we take to accommodate growth can lead us in many directions. Vision California provides the information we need to make informed decisions about how and where we want to grow.*

The energy, water, fiscal, and public health challenges facing California will require taking new directions in how we invest in and develop our communities, transportation systems, and critical infrastructure. The California Global Warming Solutions Act (Assembly Bill 32) and Senate Bill 375 have set challenging targets for reducing greenhouse gases (GHGs) across the state and in its regions. Vision California is driven by the need to provide critical context for the implementation of these policies.

Vision California's statewide growth scenarios allow for clear comparisons of the impacts of different land development and transportation options.

What is Vision California?

Vision California explores the role of land use and transportation investments in meeting the environmental, fiscal, and public health challenges facing California over the coming decades. Funded by the California High Speed Rail Authority (*cahighspeedrail.ca.gov*) in partnership with the California Strategic Growth Council (*www.sgc.ca.gov*), the project is producing new scenario development and analysis tools to compare physical growth alternatives. By clearly expressing the consequences of different scenarios, Vision California's tools can inform the critical state and regional decisions that will drive California's infrastructure investments, as well as inform and sync with improvements to regional (MPO) travel models.

* *California DOF and EDD-based projections.*

Vision California will:

- Frame California's development issues in a comprehensive manner, illustrating the role of land use in meeting greenhouse gas (GHG) reduction targets through robust analysis.
- Illustrate the connections between land use and other major challenges, including water and energy use, housing affordability, public health, farmland preservation, infrastructure provision, and economic development.
- Clearly link land use and infrastructure priorities to mandated targets as set forth by AB 32, SB 375, and the California Air Resources Board (CARB).
- Produce scalable tools, for use by state agencies, regions, local governments, and the non-profit community, which can defensibly measure the impacts of land use and transportation investment scenarios – including those represented by the regions' SB 375-mandated Sustainable Communities Strategies.
- Build upon Blueprints and other regional plans to produce statewide growth scenarios that go beyond regional boundaries and assess the combined impact of these plans.
- Connect state and national goals for energy independence, energy efficiency, and green job creation to land use and transportation investments.
- Highlight the unique opportunity presented by California's planned High Speed Rail network in shaping growth and other investments.

Rev. 06-26-2011

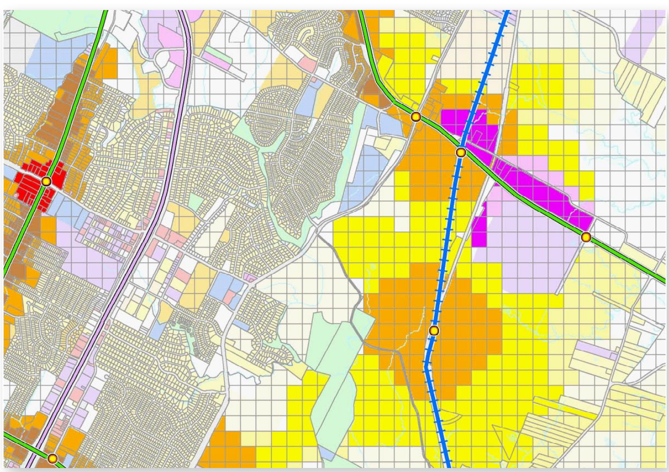
CALIFORNIA HIGH-SPEED RAIL AUTHORITY
California Natural Resources Agency
California Health & Human Services Agency
California Environmental Protection Agency
CALTHORPE ASSOCIATES
URBAN DESIGNERS, PLANNERS, ARCHITECTS

OVERVIEW of VISION CALIFORNIA MODELING TOOLS

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.

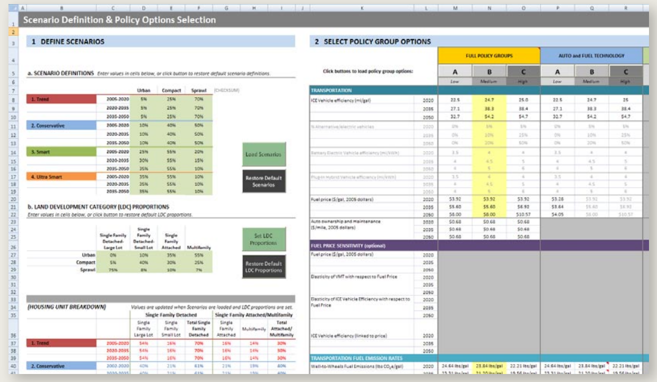
The *Urban Footprint* Map-Based Model

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. Scenarios are defined through the application of 'Place Types' to the environment. The model's suite of Place Types represents a complete range of development types and patterns, from higher density mixed-use centers, to separated-use residential and commercial areas, to institutional and industrial areas. The physical and demographic characteristics associated with the Place Types are used to calculate the impacts of each scenario. 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

The *Rapid Fire* model is a user-friendly spreadsheet-based tool which produces and evaluates high-level statewide and/or regional scenarios. It allows for efficient, iterative, and transparent testing of different combinations of compact, urban, and more sprawling growth 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 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. See inset for more information.



The Rapid Fire Modeling Framework

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 and fiscal performance. The transparency of the model's framework of input assumptions makes it readily adaptable to different study areas, as well as responsive to data emerging from ongoing technical analyses by state and regional agencies.

The model allows users to create scenarios at national, statewide, or regional scales and produces results for a range of metrics including:

- GHG (CO_2e) emissions from cars and buildings
- Air pollution and public health impacts
- Fuel use and cost
- Building energy and water use, and cost
- Land consumption
- Fiscal impacts: capital infrastructure costs, operations and maintenance costs, and local revenues

Results are summarized so that users can easily compare the impacts of different scenarios. All assumptions are clearly identified and can be easily modified.

The *Rapid Fire* model is not meant to replace more complex travel models or map-based models. Rather, it was designed to fill a timely need for defensible comparative analysis to inform state and regional entities as they analyze and develop plans and policies. A detailed description of the Vision California *Rapid Fire* model can be found in the *Rapid Fire Model White Paper and Technical Guide*.

CALIFORNIA *RAPID FIRE* SCENARIOS and MODEL RESULTS

Combining Land Use and Policy Options

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 reaches towards 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 and 24 million jobs. This report compares the four distinct scenarios described below. The land use and policy components are described in greater detail on the following pages.

LAND USE OPTIONS	POLICY OPTIONS: ***TREND***	POLICY OPTIONS: ***GREEN***
TREND	**A1** TREND POLICY / TREND GROWTH **"BUSINESS AS USUAL"** This scenario combines the trend land use patterns of past decades with a very moderate set of trend-based 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.	
MIXED	**B1** TREND POLICY / MIXED GROWTH **"MIXED GROWTH"** This scenario tests a future in which roughly half of new growth is accommodated in compact and urban forms. This land use pattern is combined with the "Trend" policy set.	
SMART	**C1** TREND POLICY / SMART GROWTH **"GROWING SMART"** In this scenario, the state sees an increasing proportion of urban infill and compact growth. This land use pattern is combined with the same trend-based policy set as for the Business as Usual scenario.	**C2** GREEN POLICY / SMART GROWTH **"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 CA Air Resources Board, CA Energy Commission, CA 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 these options is defined by the proportion of growth allocated to Urban, Compact, and Standard 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. They are described generally below.

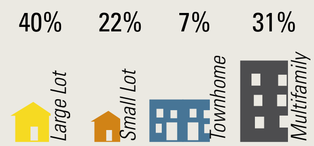
Land Development Categories

	Land Use Characteristics	Transportation Infrastructure
URBAN	Most intense and most mixed LDC, often found within and directly adjacent to moderate and high density urban centers. Virtually all 'Urban' growth would be considered infill or redevelopment. The majority of housing in Urban areas is multifamily and attached single family (townhome), with some small-lot single family homes. These housing types 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 range: ~ 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. The Compact form is 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 in Compact areas 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 range: ~ 4,000 to 7,500 per year.
STANDARD	Represents the majority of separate-use auto-oriented development that has dominated the American suburban landscape over the past decades. Densities tend to be lower than Compact LDC, and are generally not highly mixed or organized to facilitate walking, biking, or transit service. Can contain a wide variety of housing types, though medium- and larger-lot single family homes comprise the majority of this development form; these larger single family tend to consume more energy and water than those in the Urban or Compact LDCs.	Not typically well served by regional transit service and most trips are made via automobile. Per-capita VMT range: ~ 9,500 to 18,000 per year.

THREE LAND USE OPTIONS

The Rapid Fire land use options are defined according to their proportions of the three Land Development Categories. All options accommodate the same amounts of housing unit and job growth. The pie charts below show the composition of growth in each land use option by 2050, which in turn result in different housing type mixes. The housing type mix for new growth in each option is shown in the upper bar charts. The total end-state housing type mix in 2050 – new development plus the existing housing stock – is shown in the lower charts.

Housing Mix

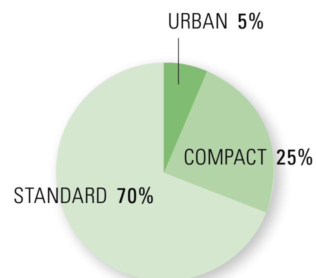


Existing Housing Mix (2005)

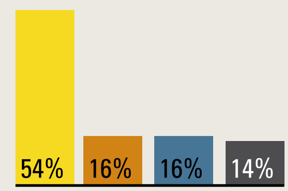
Land Use Option A. Trend Growth

LDC Proportions

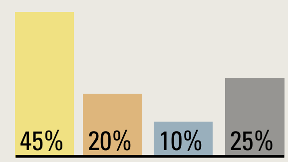
The Trend Growth option represents a future based on historic market trends, development patterns, and transportation investments in California.[2, 3, 4] This option is comprised of 70% Standard development, with Compact and Urban development totaling 30%. The resulting housing type mix aligns with historic market trends in California, in which single family detached homes have comprised the majority of new construction in major metropolitan areas.[5]



New Growth to 2050



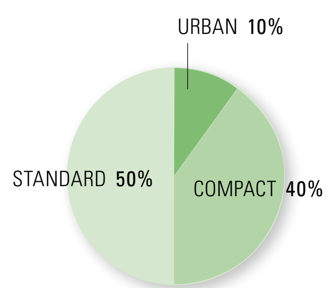
New Growth to 2050



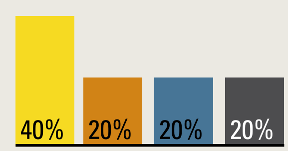
Total in 2050

Land Use Option B. Mixed Growth

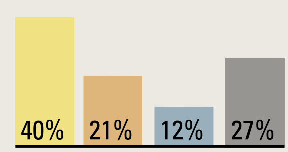
The Mixed Growth option reflects the least-aggressive end of projected market and development trends, which indicate that 50-70% of development in California between 2010 and 2020 should be Compact or Urban. These trends stem from changing demographics and lifestyles, trends in construction, the undersupply of compact units on the market, and projected energy price increases. The Mixed Growth option accommodates 50% of growth in Compact or Urban forms. It is assumed that growth will be supported by transportation investments that balance roadway and transit infrastructure, and a move towards planning for compact development by regions and cities.



New Growth to 2050



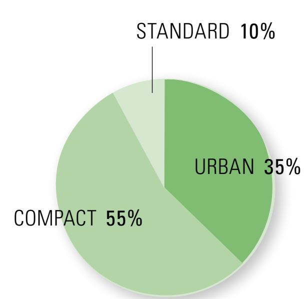
New Growth to 2050



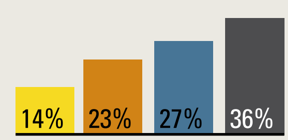
Total in 2050

Land Use Option C. Smart Growth

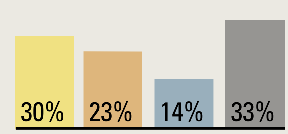
The Smart Growth option assumes that a greater share of new growth will occur in Urban and Compact forms to meet a current and projected undersupply of compact development and align with projected demographic, regulatory, and market trends.[6] This option accommodates 55% of new growth in Compact and 35% in Urban forms by 2050. Despite these high proportions, the 2050 end-state housing mix of the Smart Growth option tracks the current (2005) housing mix, with nearly 70% of housing in single family detached or attached (townhome) types. It is assumed that significant investments in transit and other infrastructure will be made to support smart growth.



New Growth to 2050



New Growth to 2050



Total in 2050

CHANGING HOUSING PREFERENCES and DEMAND

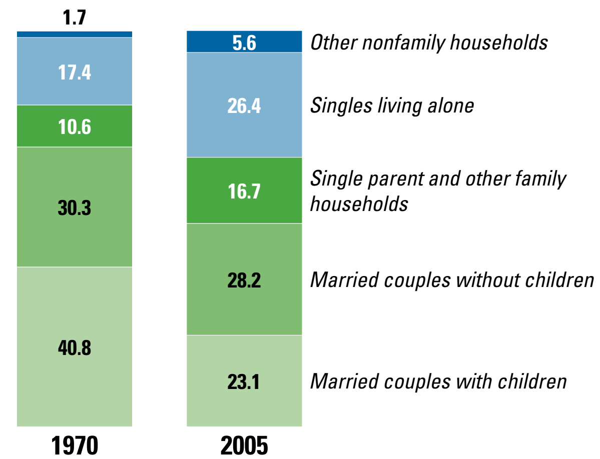
The proportion of housing types in the Mixed Growth and Smart Growth land use options are supported by real estate market analysis that indicates that demand is moving away from larger single-family detached homes toward smaller detached or attached housing units.[7] Affordability, accessibility, and demographics are key factors behind this change. Nationally, market analysts predict that apartment and townhouse living near transit will drive much housing demand going forward.[8] Lifestyle preferences also play a role: a survey of Atlanta households found that 40% of those living in single family detached neighborhoods would trade large lots for smaller ones with more community-friendly amenities, including sidewalks, narrower streets, shops and services, and parks.[9]

Changes in housing preference are also grounded in demographic changes. Married couples with children, the primary market for single-family detached homes, now account for only 23% of all households nationwide, a proportion that continues to shrink each year.[10] By contrast, the proportion of singles, single parents, empty nesters, and seniors – who generally prefer more compact single family and multifamily housing types[11] – has grown steadily.

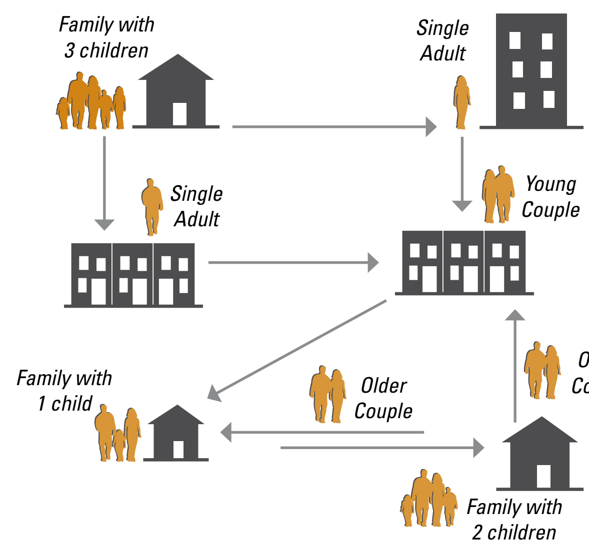
Further analysis indicates an ongoing disconnect between housing type supply and demand; despite demographic trends and expressed preferences, single family homes accounted for the majority of new construction over the last decade. A 2006 study by Arthur Nelson finds that "the market demand for new homes through 2025 may be almost exclusively for attached and small-lot units."[12] As summarized in the table at lower right, Nelson estimates a national *oversupply* of one million large-lot single family units to 2025 – that is, there are already more large-lot units existing today than will be needed by 2025. By contrast, demand for small-lot single family and attached units is very high.

For numerous reasons, including affordability, accessibility, and quality of life issues, housing preferences are changing. A recent EPA study finds that in the years since 2005, while overall residential construction has declined sharply, construction of new high-density residential units has not declined from the 200,000-unit-per-year rate of production seen at the height of the real estate boom in 2005. Similarly, construction of multifamily rental units has increased slightly through 2008; and in many regions across the country, there has been a dramatic increase in the share of new construction built in central cities and older suburbs, as opposed to at the urban fringe.[13] The oversaturation of larger single-family homes in the market has been underscored by the recent foreclosure crisis: in California, the homes most susceptible to foreclosure have been detached single-family homes located in suburban development patterns.[14] By contrast, the homes that have weathered the crisis and continue to be in demand tend to be located in compact communities.[15] The related trends of changing household demographics and growing preference for compact housing types have informed the housing unit mix composition of the Rapid Fire scenarios.

Change in U.S. household demographics, 1970-2005
Source: US Census Bureau, 2005



The Housing Life Cycle



Projected National Housing Demand to 2025 by Unit Type
Source: Nelson, 2006

Unit Type	Existing Units (2003)	Demand (2025)	**Net New Units Needed by 2025**
Attached	27,000,000	44,000,000	**17,000,000**
Small Lot[16]	22,000,000	40,000,000	**18,000,000**
Large Lot[17]	57,000,000	56,000,000	**- 1,000,000**

POLICY PACKAGES

The Rapid Fire 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 their development and implementation.

Policy Package 1: Trend Policy

The Trend policy package assumes very moderate, trend-based improvements in vehicle fuel economy, the carbon intensity of fuel, building energy and water efficiency, and the proportion of renewable power[18] used by utilities in their power generation portfolio. This policy set is an important component of any business-as-usual future and serves 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.

The core components of each policy package are outlined in the table below. 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*.

	Policy Package 1: TREND POLICY			**Policy Package 2: GREEN POLICY**		
	2020	**2035**	**2050**	**2020**	**2035**	**2050**
Transportation						
Fuel economy	24 mpg gas eq.[i,ii,iii]	27 mpg	28 mpg	25 mpg	38 mpg	54 mpg
	Meets Pavley I Clean Car Standard			*Meets Pavley I and II, with continued improvement after 2020*		
Fuel price	$4.00/gal[iv]	$5.50	$8.00	$4.00	$5.50	$8.00
	Reflects 2.4% annual increase in price			*Reflects 2.4% annual increase in price*		
Buildings						
Energy use of new buildings	10% below 2005	20%	30%	30%	55%	80%
	Reflects modest efficiency improvements			*Reflects strong policy for efficiency improvements*		
Energy use of existing buildings	0.5% less per year	0.5%	0.5%	0.75%	1.25%	2%
	Reflects modest policy for building retrofits			*Reflects strong policy for building retrofits*		
Electricity price	$0.17/kWh	$0.18	$0.18	$0.18	$0.20	$0.22
	Reflects increase related to moderate growth in renewables			*Reflects increase related to high growth in renewables*		
Natural gas price	$1.71/therm	$2.30	$3.10	$1.71	$2.30	$3.10
	Reflects a trend-based 2% annual increase in price			*Reflects a trend-based 2% annual increase in price*		
Water use of new residential buildings	10% below 2005	20%	30%	30%	50%	70%
	Reflects modest efficiency improvements			*Reflects strong policy for efficiency improvements*		
Water use of existing buildings	10% below 2005	15%	20%	25%	35%	50%
	Reflects modest policy for building retrofits			*Reflects strong policy for building retrofits*		
Water price	$1,050/AF	$1,250	$1,450	$1,050	$1,250	$1,450
	Reflects a 1.1% annual increase in price			*Reflects a 1.1% annual increase in price*		
Energy Emissions						
Transportation fuel emissions	17.7 lbs CO_2e/gal ge	17.7 lbs	17.7 lbs	17.7 lbs	13.7 lbs	9.8 lbs
	Reaches Low Carbon Fuel Standard 10% reduction goal by 2020			*Reaches LCFS 10% goal by 2020, with continued improvement to 2050*		
Electricity emissions	0.69 lbs/kWh	0.62 lbs	0.58 lbs	0.58 lbs	0.48 lbs	0.35 lbs
	Reflects increase in renewables to 33% in 2050			*Reflects increase in renewables to 60% in 2050*		
Natural gas emissions	11.7 lbs/therm	11.7 lbs	11.7 lbs	11.7 lbs	11.7 lbs	11.7 lbs
	Reflects constant rate of on-site combustion emissions			*Reflects constant rate of on-site combustion emissions*		

Notes:
i) Fuel economy and fuel emission rate projections are based on California's currently adopted vehicle and fuel standards (Pavley I Clean Car Standard and Low Carbon Fuel Standard).
ii) Values are rounded. For exact assumption values, refer to the Rapid Fire Model White Paper and Technical Guide.
iii) Throughout report, all fuel metrics are expressed in terms of gasoline equivalent (ge).
iv All price assumptions are in 2008 dollars.

LAND CONSUMPTION

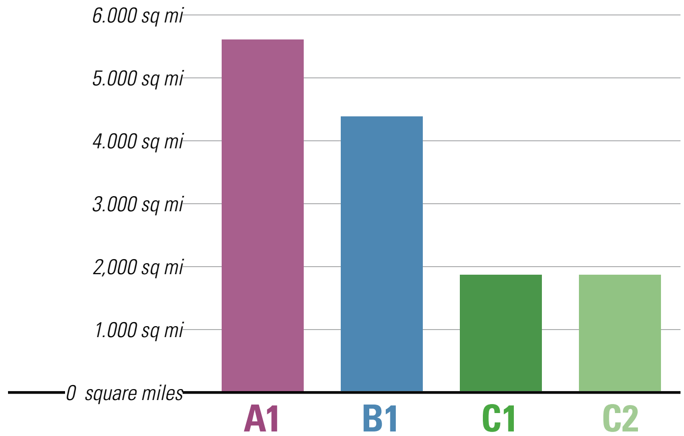
New Land Consumed

Land Consumption

The amount of land consumed to accommodate new population growth varies substantially among the Rapid Fire scenarios. New land consumption includes all land that will be newly urbanized, including residential and employment areas, roadways, open space, and public lands. The Rapid Fire model estimates land consumption based on per-capita rates of land consumption by Land Development Category (Urban, Compact, and Standard).

Scenario A1, which accommodates 70% of growth through 2050 in the Standard LDC, consumes more than twice the land of Scenarios C1 and C2, which accommodate from 80% to 90% of new growth in the Compact and Urban LDCs. The 'C' Scenarios 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.

Cumulative New Land Consumption to 2050



Cumulative New Land Consumption

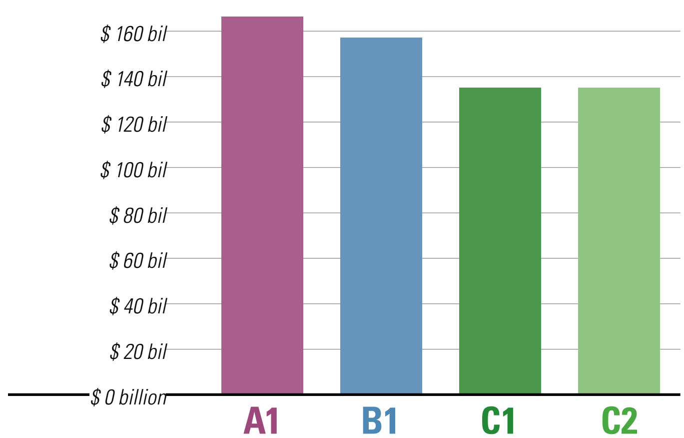
	2035	2050
A1 BUSINESS AS USUAL	3,700 sq mi	5,600 sq mi
B1 MIXED GROWTH	2,920 sq mi	4,370 sq mi
C1 GROWING SMART	1,390 sq mi	1,850 sq mi
C2 GREEN FUTURE	1,390 sq mi	1,850 sq mi

Capital Infrastructure Costs

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 parks. 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. When comparing Scenario A1 to Scenarios C1 and C2, local and sub-regional infrastructure cost savings add up to more than $4,000 per new household by 2050 – a cumulative savings of more than $18 billion through 2035, and $32 billion through 2050.

Note that the capital infrastructure costs and other fiscal impacts detailed here represent those associated with residential growth only. The Rapid Fire model does not yet analyze the fiscal impacts of non-residential growth; these would provide a clearer picture of cost variations among land use patterns. It is expected that the inclusion of non-residential fiscal impacts would compound the cost and revenue differences that have been evidenced between dispersed and compact development patterns.

Cumulative Capital Infrastructure Costs to 2050 (2008 dollars)



Cumulative Capital Infrastructure Costs

	2035	2050
A1 BUSINESS AS USUAL	$109 bil	$165 bil
B1 MIXED GROWTH	$105 bil	$158 bil
C1 GROWING SMART	$90 bil	$133 bil
C2 GREEN FUTURE	$90 bil	$133 bil

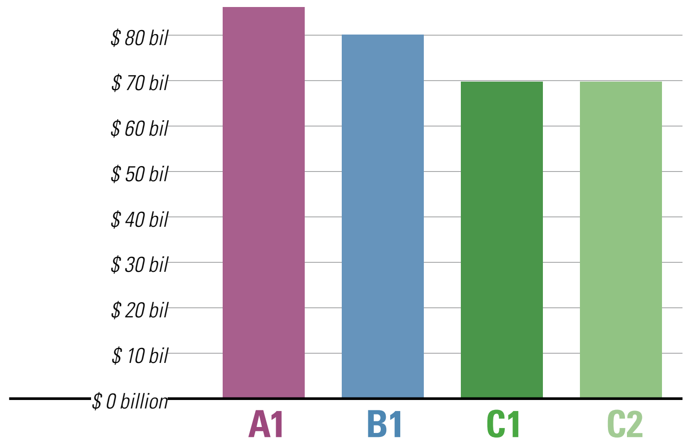
FISCAL IMPACTS

Capital Infrastructure Costs, Operations and Maintenance Costs, and Local Revenues

Operations and Maintenance Costs

Operations and maintenance (O&M) costs include the ongoing city General Fund expenditures required to operate and maintain the infrastructure serving new residential growth. These engineering and public works costs are strongly linked to the physical form of infrastructure. More dispersed development, which entails greater lengths of roads and sewer pipes, incur higher costs to local jurisdictions than more compact development, which capitalizes on the economic efficiencies of shared infrastructure capacity. When comparing Scenario A1 to Scenarios C1 and C2, local and sub-regional infrastructure cost savings add up to a cumulative savings of more than $6 billion through 2035, and $15 billion through 2050.

Cumulative Operations and Maintenance Costs to 2050 (2008 dollars)



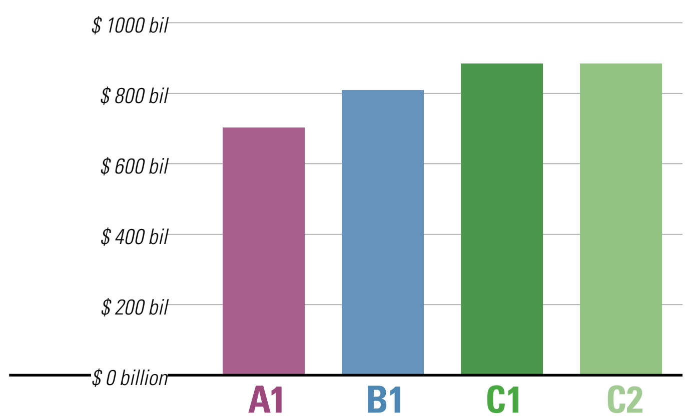
Cumulative Operations and Maintenance Costs

	2035	2050
A1 BUSINESS AS USUAL	$38 bil	$85 bil
B1 MIXED GROWTH	$36 bil	$80 bil
C1 GROWING SMART	$32 bil	$70 bil
C2 GREEN FUTURE	$32 bil	$70 bil

Local Revenues

The model estimates potential revenues from property and property transfer taxes, sales taxes, and vehicle license fees generated by new housing units. Due to the price premiums of higher-intensity locations, more compact development generates significantly higher local revenues than more dispersed development. This is true on both a per-unit and per-acre basis – by 2050, Scenarios C1 and C2 generate nearly $14,000 more per acre, per year than Scenario A1. Comparing the cumulative revenues of Scenario A1 with Scenarios C1 and C2 demonstrates the magnitude of these benefits: the revenues of Scenarios C1 and C2 add up to an additional $53 billion through 2035, and $120 billion through 2050.

Cumulative Local Revenues to 2050 (2008 dollars)



Cumulative Local Revenues

	2035	2050
A1 BUSINESS AS USUAL	$331 bil	$744 bil
B1 MIXED GROWTH	$358 bil	$804 bil
C1 GROWING SMART	$385 bil	$865 bil
C2 GREEN FUTURE	$385 bil	$865 bil

TRANSPORTATION

Vehicle Miles Traveled

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. 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.[19]

Vehicles Miles Traveled (VMT)

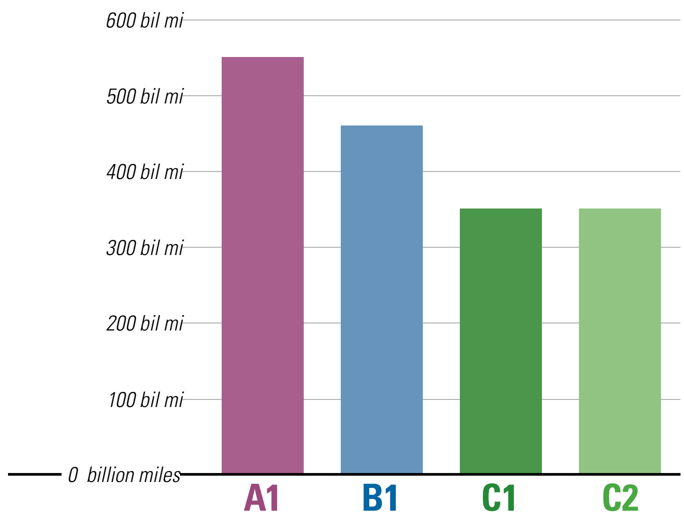
The Rapid Fire model calculates VMT by applying assumptions about per-capita annual VMT to population growth. These assumptions, which differ by Land Development Category, are based on research and empirical evidence that per-capita VMT of both incremental (new) population and base year (existing) population vary based on the form of new growth.[20] Moreover, this variation is expected to change over time as areas become either more urban or compact, or more sprawling (determined based on the proportions of LDCs in a scenario).

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 destinations and services are closer.

It is an *a priori* assumption of the Rapid Fire model that requisite transportation investments go hand in hand with growth patterns, such that scenarios with a greater focus on Compact and Urban development would see increased transit, bicycle, pedestrian, streetscape, and livability investments. Conversely, scenarios dominated by Standard development would see large budget outlays to highway and road expansion.

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, see much higher VMT rates than Scenarios B and C. Total annual VMT in the C scenarios is 38% lower than that in Scenario A1 in 2050. Average per-capita passenger VMT in 2050 ranges from 9,160 in A1, to 7,850 in B1, to 5,660 in C1 and C2. Note that VMT is determined by the land use option in a scenario, and is independent of the policy packages selected; C1 and C2, with the same land use option, result in identical VMT estimates.

Total Annual Vehicle Miles Traveled in 2050



Annual VMT per Capita

	2005	2035	2050
A1 BUSINESS AS USUAL	8,100 mi	8,870 mi (+ 10%)	9,160 mi (+ 13%)
B1 MIXED GROWTH	8,100 mi	7,850 mi (- 3%)	7,850 mi (- 3%)
C1 GROWING SMART	8,100 mi	6,440 mi (- 20%)	5,660 mi (- 30%)
C2 GREEN FUTURE	8,100 mi	6,440 mi (- 20%)	5,660 mi (- 30%)

Pricing Effects

Fuel price, along with other driving costs, have both short- and long-term effects on driving decisions. Research into historic patterns has quantified relationships among the interrelated factors of VMT and automobile fuel economy with costs including fuel price, fuel taxes, automobile ownership, insurance, and maintenance costs, and parking, toll, and congestion charges. The results, expressed as an "elasticity" of change in one factor with respect to change in another, can be used to estimate the effects of specific policy- or program-based assumptions on VMT. Pricing elasticities have not been applied in calculating the results presented in this report; however, the Rapid Fire model does allow users to "turn on" sensitivity to changes in per-mile driving costs to estimate changes in VMT due to pricing.

TRANSPORTATION

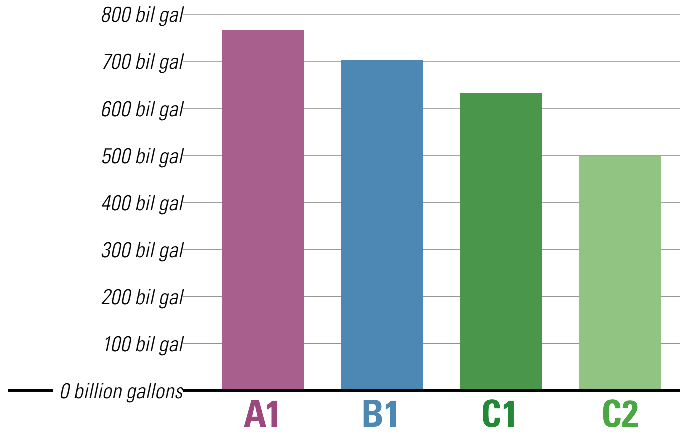
Fuel Consumption and Driving Costs

Automobile Fuel Use and Cost of Driving

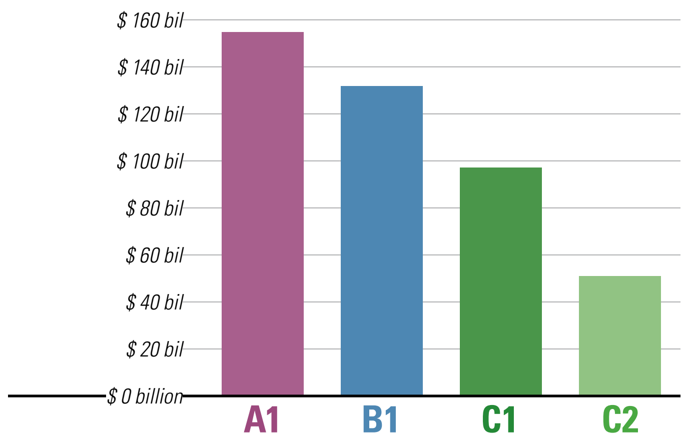
Variations in passenger VMT lead to substantial differences in the amount of automobile fuel (gasoline equivalent) used in each of the scenarios. Scenarios A1, B1, and C1, which all include the same modest vehicle fuel economy assumption, show significant differences in fuel use due to land use-related VMT variations. When combined with policy variations for automobile efficiency and fuel cost, the scenarios illustrate the combined impact of land use and policy packages. Assuming the more aggressive efficiency standards of the "green" policy set brings auto fuel use in Scenario C2 down further: annual auto fuel use in 2050 is 68% lower in C2 than in Scenario A1. Between 2005 and 2050, the savings amount to over 275 billion gallons of fuel.

Reduced VMT and fuel use leads to lower costs for all households in California. When compared to Scenario A1, Scenario C2 saves the average California household more than $9,300 per year in driving-related costs in 2050. Statewide, the savings total $106 billion per year.

Cumulative Passenger Vehicle Fuel Consumption to 2050 (gallons gasoline equivalent)

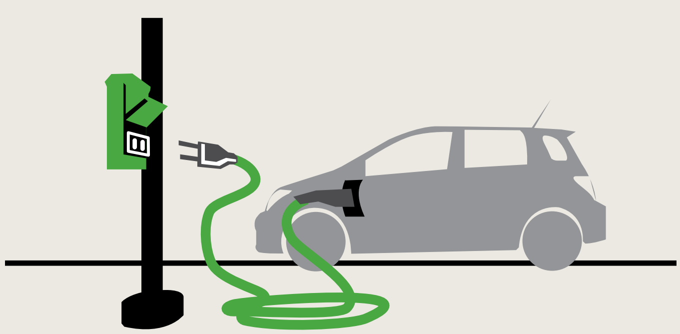


Total Annual Fuel Costs in 2050 (2008 Dollars)



Alternative Vehicle Impacts

Electric and other alternative fuel vehicles play an important role in reducing GHG emissions from transportation. These Vision California model results implicitly capture the impacts of electric vehicle use because the fuel economy and GHG emission rate assumptions used in the Rapid Fire model are based on California's adopted and/or proposed policies for improving vehicle fuel economy (California's AB 1493 Clean Car Standards, or "Pavley I", and the anticipated "Pavley II") and decreasing fuel carbon intensity (Low-Carbon Fuel Standard) – each of which assumes that growing shares of electric and other alternative fuel vehicles in the on-road fleet are necessary to reach targets. Consistent with regulatory targets, all assumptions and results for fuel use, fuel economy, and fuel emissions in the Rapid Fire model are expressed in terms of gallons of gasoline equivalent.[21]



*Annual Driving Costs per Household**

	2035	2050
A1 BUSINESS AS USUAL	$13,000	$18,200
B1 MIXED GROWTH	$11,300	$15,600
C1 GROWING SMART	$9,200	$11,200
C2 GREEN FUTURE	$8,000	$8,900

** Driving costs include fuel and auto ownership, maintenance, and insurance costs calculated on an average per-mile basis.*

TRANSPORTATION

Greenhouse Gas and Air Pollutant Emissions

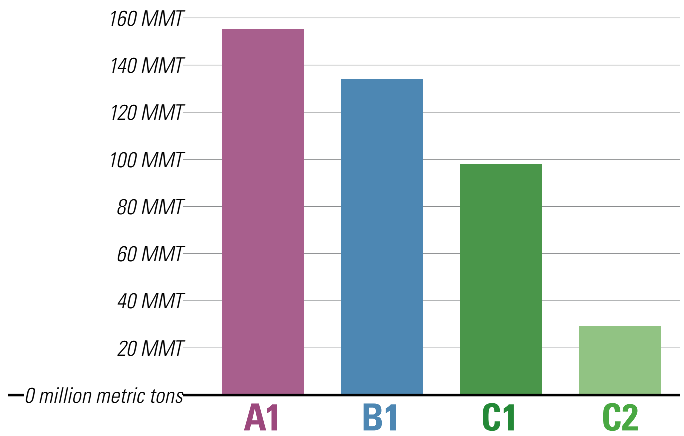
GHG Emissions from Passenger Vehicles

GHG emissions from passenger vehicles are determined 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 the same Trend-based policy set, reveal the emissions differences among land use options. Scenario C2 demonstrates the additional impact of adding the Green policy package to a Smart Growth future.

Scenario C1 highlights the significant impact of land use on vehicle GHG emissions, with 2050 emissions that are 38% 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 82% lower than those of A1. The results across all scenarios highlight the need to seek reductions through both compact land patterns and progressively stronger vehicle and fuel policies to 2050.

Note that, to remain consistent with the GHG target-setting process under SB 375, the transportation emissions reported here are limited to tailpipe (tank-to-wheel) emissions. A more complete picture of emissions emerges in an analysis of full lifecycle (well-to-wheel) emissions. The Rapid Fire model estimates both combustion and lifecycle emissions.

Total Annual Transportation GHG Emissions in 2050 (MMT CO_2e)



Annual Transportation CO_2e Emissions per Capita (lbs CO_2e)

	2005	2035	2050
A1 BUSINESS AS USUAL	8,500 lbs	5,800 lbs (- 32%)	5,800 lbs (- 32%)
B1 MIXED GROWTH	8,500 lbs	5,130 lbs (- 40%)	4,970 lbs (- 42%)
C1 GROWING SMART	8,500 lbs	4,210 lbs (- 50%)	3,580 lbs (- 58%)
C2 GREEN FUTURE	8,500 lbs	2,310 lbs (- 73%)	1,020 lbs (- 88%)

Air Pollutant Emissions from Passenger Vehicles

Differences in VMT lead to different levels of air pollutants (including nitrogen oxides, carbon monoxide, sulfur dioxide, volatile organic compounds, and particulate matter) among the Rapid Fire scenarios. The California Air Resources Board assumes that rates of these pollutants will decline over time, as vehicle technology improves. With higher VMT, Scenario A1 sees 2035 passenger-vehicle pollutant emissions that are 27% higher than emissions in Scenario C2. By 2050, changes in vehicles and fuels are expected to dramatically reduce emissions per mile.

Total Annual Air Pollutant Emissions

	2005	2035	2050*
A1 BUSINESS AS USUAL	2,525,200 tons	587,200 tons	626,570 tons
B1 MIXED GROWTH	2,525,200 tons	519,770 tons	537,200 tons
C1 GROWING SMART	2,525,200 tons	426,480 tons	387,480 tons
C2 GREEN FUTURE	2,525,200 tons	426,480 tons	387,480 tons

** Air pollutant emission rate assumptions are based on statewide EMFAC projections to 2040, which decline significantly. EMFAC rates for 2040 are assumed for 2050, since pure extrapolation would see pollutant emission rates approach zero.*

PUBLIC HEALTH

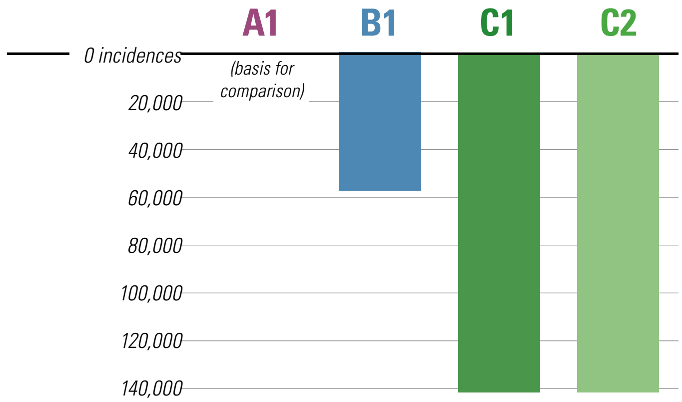
Health Incidences and Costs

Health Incidences and Costs

Auto-related air pollution results in a spectrum of health incidences, including cases of chronic bronchitis; acute myocardial infarction; respiratory and cardiovascular hospitalizations; respiratory-related ER visits; acute bronchitis; work loss days; premature mortality; asthma exacerbation; and acute, lower, and upper respiratory symptoms. Health incidences, and their related costs, are reduced along with miles driven. The Rapid Fire model estimates savings (rather than absolute totals) in health incidences and costs to 2035 according to research-based rates and valuations[22].

Scenarios C1 and C2 highlight the significant impact of land use on public health impacts. Relative to Scenario A1, they reduce the total number of health incidences by 27%, or 142,800 incidences in 2035. In terms of health costs, Scenarios C1 and C2 save 27% annually, or $1.9 billion in 2035.

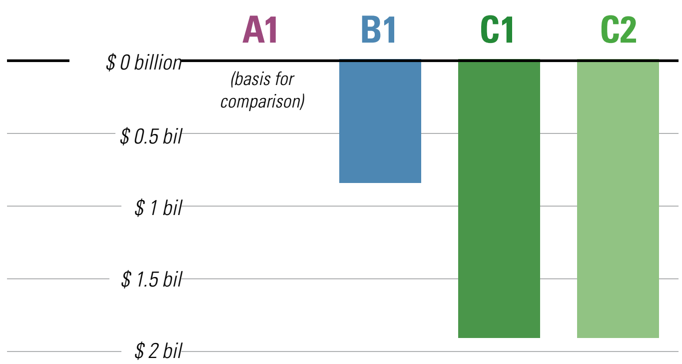
Reductions in Total Annual Health Incidences in 2035



Reductions in Total Annual Health Incidences

		2035
A1	BUSINESS AS USUAL	0 (basis for comparison)
B1	MIXED GROWTH	-59,900 (- 11%)
C1	GROWING SMART	-142,800 (- 27%)
C2	GREEN FUTURE	-142,800 (- 27%)

Reductions in Total Annual Health Costs in 2035 (2009 dollars)



Reductions in Total Annual Health Costs in 2035

		2035
A1	BUSINESS AS USUAL	0 (basis for comparison)
B1	MIXED GROWTH	$815 million (- 11%)
C1	GROWING SMART	$1.9 billion (- 27%)
C2	GREEN FUTURE	$1.9 billion (- 27%)

RESIDENTIAL and COMMERCIAL BUILDING ENERGY

Energy Consumption, Cost, and Greenhouse Gas Emissions

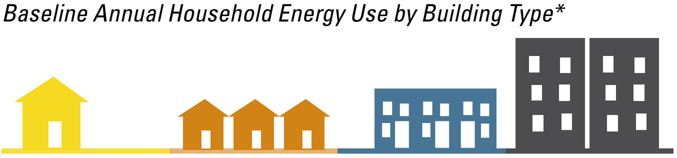
The Vision California Rapid Fire scenarios vary in their residential and commercial energy use profiles due to their building program and policy assumptions. Scenarios B1, C1, and C2, which include a larger proportion of Compact and Urban development, accommodate a higher proportion of growth in more 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.

Energy Consumption, Cost, and 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. Energy use varies by building type, and according to changing policies for building efficiency .

The smart land use of Scenario C1 brings energy use in 2050 to 15% lower than that of Scenario A1, which has the same policy assumptions but a more sprawling, trend-based land pattern. Applying Green building and energy policies in Scenario C2 increases this annual difference to 43%. The cumulative residential 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.

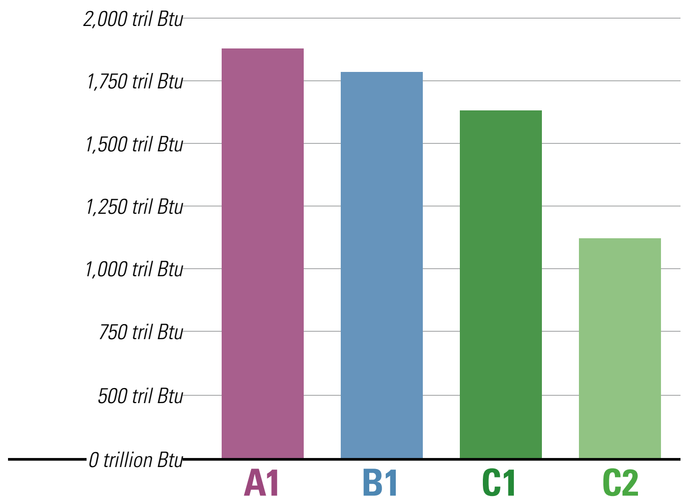
*Baseline Annual Household Energy Use by Building Type**



Large Lot Single Family	Small Lot Single Family	Attached Single Family	Multifamily
100 million Btu	71 million Btu	54 million Btu	38 million Btu

** Includes residential electricity and natural gas use. Statewide baseline average consumption data derived from California Energy Commission Statewide Residential Appliance Saturation Survey (RASS), 2004.*

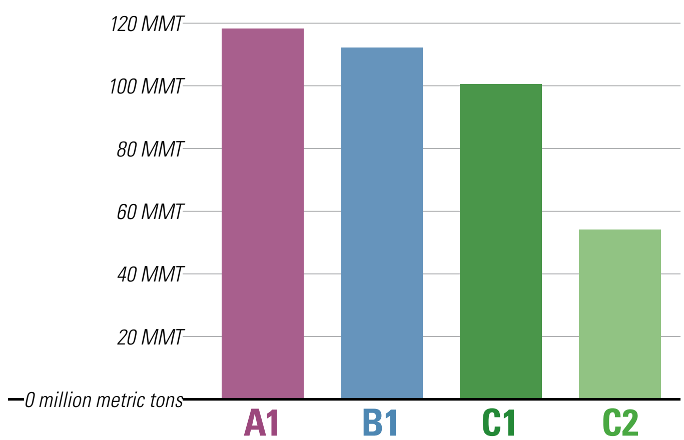
Annual Residential and Commercial Building Energy Use in 2050 (Btu)



Annual Residential Energy Consumption per Household

	2035	2050
A1 BUSINESS AS USUAL	60 mil Btu	58 mil Btu
B1 MIXED GROWTH	58 mil Btu	56 mil Btu
C1 GROWING SMART	55 mil Btu	52 mil Btu
C2 GREEN FUTURE	45 mil Btu	39 mil Btu

Total Annual Residential and Commercial Building Energy CO_2e Emissions in 2050 (MMT CO_2e)



Annual Residential Building Energy Emissions per Household

	2035	2050
A1 BUSINESS AS USUAL	8.400 lbs	7,700 lbs
B1 MIXED GROWTH	8.150 lbs	7,400 lbs
C1 GROWING SMART	7,700 lbs	6,850 lbs
C2 GREEN FUTURE	5,700 lbs	3,850 lbs

RESIDENTIAL WATER

Water Consumption, Costs, and Greenhouse Gas Emissions

The building program and policy variations among the Vision California Rapid Fire scenarios lead to significant 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.

Residential water use in Scenario C1, with smart land use and trend policies, is almost 10% lower than that of 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. The average household uses 40,000 gallons less per year by 2035, and 55,000 gallons less per year by 2050. Cumulative 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.

GHG Emissions from Water-Related Energy Use

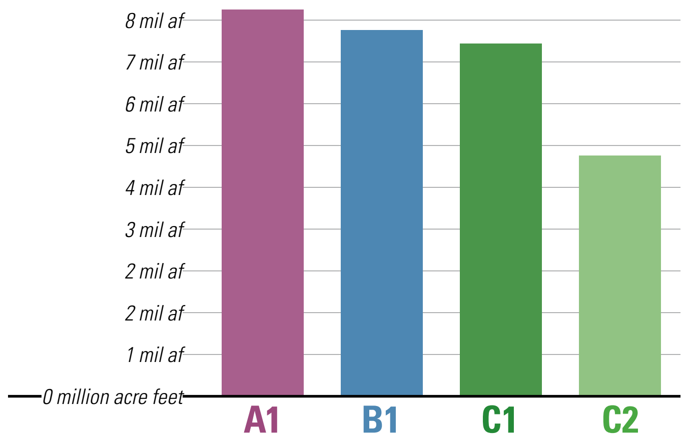
Water-related GHG emissions result from two main categories of energy use: a) system uses, including the transport, treatment, and distribution of water consumed; and b) end uses, including all uses of water that occur within homes (e.g., water heating).[23] The Rapid Fire model calculates energy use 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 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.

*2005 Annual Household Water Use by Building Type**

Large Lot Single Family	**Small Lot Single Family**	**Attached Single Family**	**Multifamily**
194,000 gal	125,000 gal	93,000 gal	89,000 gal

** Statewide baseline average consumption figures include indoor and outdoor water use. Indoor use is based on per-capita averages; outdoor use is based on generalized assumptions about landscape area and irrigation requirements.*

Total Annual Residential Water Use in 2050



Annual Residential Water Use per Household

	2035	2050
A1 BUSINESS AS USUAL	141,500 gal	133,600 gal
B1 MIXED GROWTH	137,850 gal	129,050 gal
C1 GROWING SMART	131.450 gal	120,400 gal
C2 GREEN FUTURE	101,150 gal	78,150 gal

Annual Water-Related Emissions for Residential Water Use (MMT CO_2e)

	2035	2050
A1 BUSINESS AS USUAL	5.7 MMT	5.8 MMT
B1 MIXED GROWTH	5.6 MMT	5.6 MMT
C1 GROWING SMART	5.3 MMT	5.2 MMT
C2 GREEN FUTURE	3.1 MMT	2.1 MMT

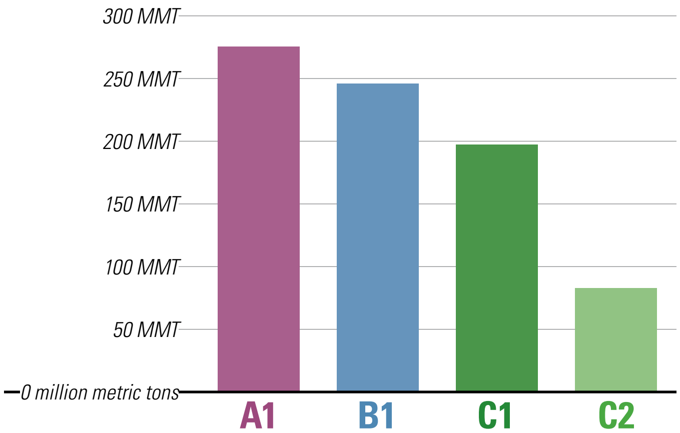
GREENHOUSE GAS EMISSIONS SUMMARY

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.

Greenhouse Gas 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.

Total Annual Transportation and Building Energy GHG Emissions in 2050 (MMT CO_2e)



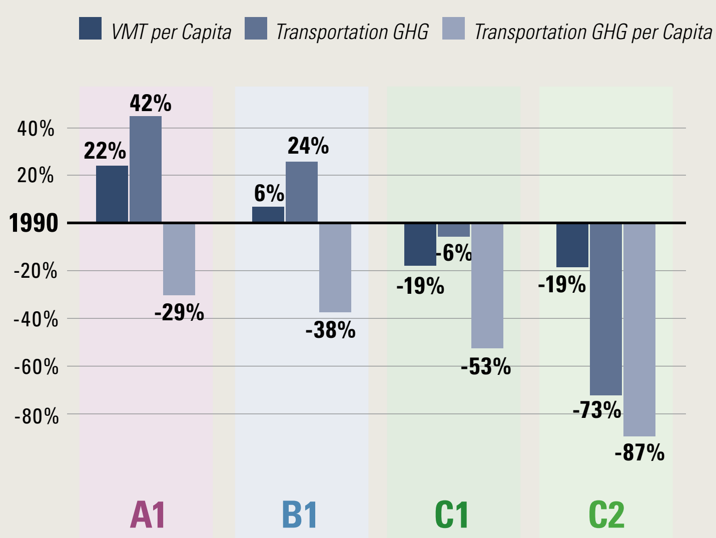
Total Annual GHG Emissions from Transportation and Buildings (MMT CO_2e)

	2005	2035	2050
A1 BUSINESS AS USUAL	247 MMT	250 MMT (1%)	274 MMT (11%)
B1 MIXED GROWTH	247 MMT	230 MMT (- 7%)	246 MMT (- 0.4%)
C1 GROWING SMART	247 MMT	201 MMT (- 19%)	198 MMT (- 20%)
C2 GREEN FUTURE	247 MMT	128 MMT (- 48%)	83 MMT (- 66%)

From VMT to GHG

As demonstrated by the results of the Rapid Fire statewide scenarios, land use planning and policy act in conjunction to reduce emissions to meet our state goals. The chart at right shows the relative change in per-capita VMT from 1990 to 2050 alongside changes in total and per-capita GHG emissions. The results across the four scenarios illustrate both the separate and combined impacts of land use (affecting VMT) and auto and fuel policies (affecting fuel use and amount of GHG emissions per gallon). Only Scenario C2, which combines smart land use with progressive policies for vehicle technology and fuel composition, comes close to achieving the target 80% reduction in total transportation GHG emissions from 1990 levels by 2050.

VMT per Capita and Total per Capita Transportation GHG Emissions, 2050 vs. 1990



COST SUMMARY

Household Expenditures and Infrastructure 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 costs, as well as household transportation, energy, and water costs, are much higher in scenarios with greater land consumption, higher VMT, and building programs that rely more on larger lot single family construction.

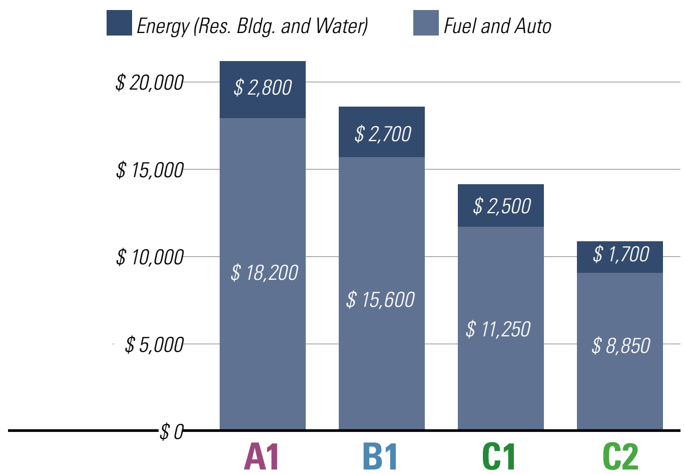
Thus, Scenario A1 exhibits the highest total costs. Comparing the three scenarios with the same Trend policy set isolates the impact of land use on total cost; Scenario C1, with the lowest land consumption and VMT, and the most resource-efficient building program, saves more than $1 trillion by 2035 over Scenario A1, and more than $2.6 trillion by 2050. Adding the Green policies in Scenario C2 extends these savings to more than $1.7 trillion by 2035 and more than $4 trillion by 2050.

Average Annual Household Expenditures: Fuel and Auto Costs, Residential Electricity, Gas, and Water

	2035	2050
A1 BUSINESS AS USUAL	$15,500	$21,000
B1 MIXED GROWTH	$13,800	$18,300
C1 GROWING SMART	$11,500	$13,750
C2 GREEN FUTURE	$9,900	$10,550

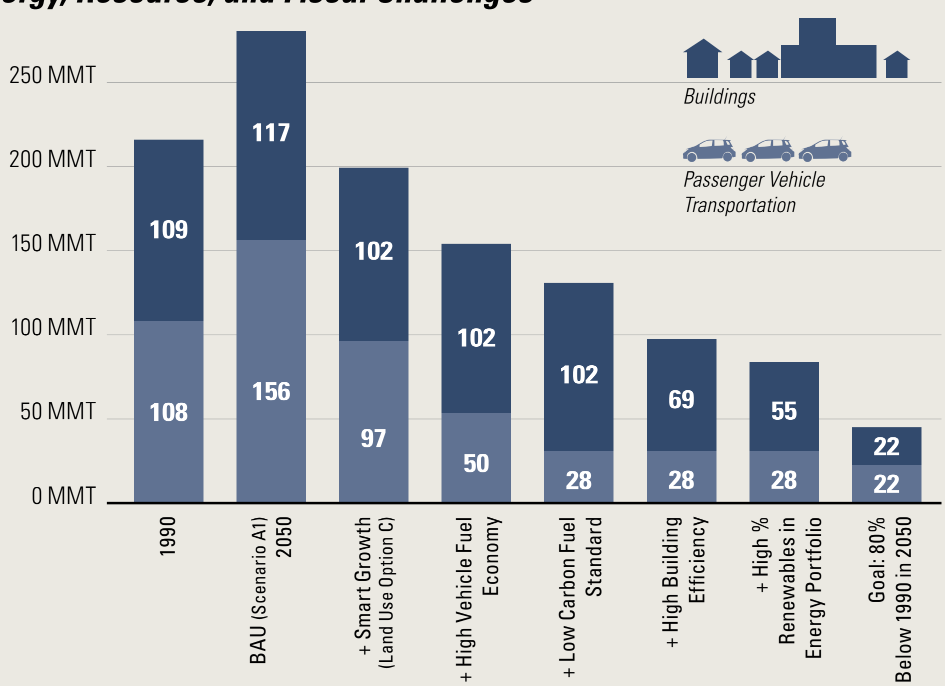
Breaking costs down to the household level exposes the impact of land use and policy choices on California households. In 2050, households in Scenario C2 save an average of $10,450 per year (compared to Scenario A1) in costs associated with driving and residential energy and water use. This difference is further exacerbated by the addition of local infrastructure cost burdens, which are typically passed on to homeowners and renters in the form of taxes, fees, home prices, and assessments. Over time, the differences in annual expenditures would amount to a significant sum for each household – money that could instead be applied to a home mortgage or other living expenses.

Total Costs per Household in 2050 (2008 dollars)



Meeting California's Climate, Energy, Resource, and Fiscal Challenges

The chart at right 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.



ENDNOTES and REFERENCES

Endnotes

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

2. 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).

3. The UC Davis Institute of Transportation Studies estimates that, under current trends, VMT per capita will increase to 9,975 by the year 2050 (Yang, McCollum, McCarthy, & Leighty, 2008).

4. Caltrans estimates that VMT will continue to increase at nearly 3 percent per year for the foreseeable future under current trends (Bartholomy, et al., 2007).

5. Between 1998 and 2004, approximately 83% of new construction in major metropolitan areas was made up of single family detached homes. (ULI, 2009)

6. According to a 2009 article in the Sacramento Bee quoting 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).

7. (ULI, 2003)

8. (ULI, 2009)

9. (Levine, Frank, & Chapman, 2004)

10. (U.S. Census Bureau, 2005)

11. (ULI, 2003)

12. (Nelson, 2006)

13. According to the study (U.S. Environmental Protection Agency, 2010), there has been an acceleration of residential construction in existing urban neighborhoods, reflecting a fundamental shift in the real estate market that is driven by lower crime rates in central cities, changing demographics, increased demand for homes in walkable communities, closer proximity to high-paying jobs, rising energy costs, pedestrian access to amenities (retail, restaurants, parks, supermarkets, etc.), and transit-oriented development.

14. (ULI, 2009)

15. From the New York Times: "Homes beyond the urban core have been falling in value faster than those within" (Goodman, 2008); "the further you get from the city, the more prices have declined" (Bajaj, 2009).

16. Includes all units (including townhouses) on lots under $^1/_8$ acre and half the units on lots between $^1/_8$ and $^1/_4$ acre. (Nelson, 2006)

17. Includes all units on lots over $^1/_6$ acre. (Nelson, 2006)

18. Within the context of this report, "renewable energy" 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.

19. Baseline 2005 statewide fleet efficiency for California was 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).

20. For a thorough description of the Rapid Fire VMT modeling methodology, including an analysis of VMT in sample LDC areas and a discussion of relevant studies, please refer to the *Rapid Fire White Paper and Technical Guide*.

21. Note that the Rapid Fire model gives users the option to separately estimate the dedicated impacts of electric vehicles and standard internal combustion engine (ICE) vehicles. Electricity demand and emissions estimates are calculated based on assumptions about the proportion of electric vehicles in the on-road fleet, and their average fuel economy. These assumptions may be guided by ongoing studies by the California Energy Commission and California Air Resources Board.

22. The Rapid Fire model public health assumptions were developed by TIAX, LLC for the American Lung Association. Assumptions are based on national data from the EPA, Office of Air Quality Planning & Standards, Air Benefit and Cost Group (August 2010), with valuations (costs) extrapolated for 2035.

23. 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 2006).

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BACKGROUND

Rapid Fire Model Output Metrics and Input Assumptions

Summary of Output Metrics

Land Consumption

- Land Consumed (square miles)

Fiscal Impacts

- Capital Costs for Roads and Wet and Dry Utility Provision ($)
- Operations and Maintenance Costs ($)
- City Revenues from Residential Development ($)

Transportation System Impacts and Emissions

- Vehicle Miles Traveled (VMT) (miles)
- Fuel Consumed (gal)
- Fuel Cost ($)
- Transportation Electricity Consumed (kWh)
- Transportation Electricity Cost ($)
- Transportation Electricity CO_2e Emissions (MMT)
- ICE Fuel Combustion CO_2e Emissions (MMT)
- ICE Full Fuel Lifecycle CO_2e Emissions (MMT)
- Criteria Pollutant Emissions (tons)

Public Health Impacts Related to Transportation Emissions

- Respiratory and Cardiovascular Health Incidences (#)
- Health Costs associated with Health Incidences ($)

Building Energy, Cost, and Emissions

- Residential Energy Consumed (Btu)
- Commercial Energy Consumed (Btu)
- Total Energy Consumed (Btu)
- Residential Building CO_2e Emissions (MMT)
- Commercial Building CO_2e Emissions (MMT)
- Residential Energy Cost ($)
- Building Water Use, Cost, and Emissions
- Water Consumed (AF)
- Water Cost ($)
- Water-Related Electricity Use (GWh)
- Water-Related Electricity CO_2e Emissions (MMT)

Total Greenhouse Gas (GHG) Emissions

- Total CO_2e Emissions (Transportation & Buildings, MMT)

Building Program

- Housing type mix

Summary of Input Assumptions

Demographics

- Baseline population and population growth
- Baseline households and household growth
- Baseline housing units and housing unit growth
- Baseline non-farm jobs and job growth

Scenarios

- Land Development Category (LDC) proportions for each scenario and time period
- Housing unit composition for each LDC

Fiscal Impacts

- Per-unit capital cost assumptions for roads and wet and dry utility provision by building type and Land Development Category (LDC)
- Per-unit operations and maintenance cost assumptions for roads, utilities, and public services by building type and LDC
- Per-unit revenue assumptions by building type and LDC

Land Consumption

- Percent greenfield vs. infill/greyfield/brownfield growth for each land development category, scenario, and time period
- Acres per capita required for greenfield development in each land development category, scenario, and time period

** Denotes an optional input which was not applied in calculating the output metrics presented in this report.*

Vehicle Miles Traveled (VMT)

- Baseline Per Capita Light Duty Vehicle (LDV) VMT
- VMT adjustment factors by LDC and scenario for growth increment population
- VMT escalation and deceleration rates for the baseline environment population
- Elasticity of VMT with respect to driving costs per mile*

Vehicle Fuel Economy and Cost

- Baseline fuel economy for total fleet, internal combustion engine vehicles alone*, and alternative/electric vehicles alone*
- Fuel economy in horizon years for total fleet, internal combustion engine vehicles alone*, and alternative/electric vehicles alone*
- Elasticity of fuel economy with respect to fuel cost*

Transportation Emissions

- Baseline fuel emissions, full lifecycle (well-to-wheel) for total fleet, internal combustion engine vehicles alone*, and alternative/electric vehicles alone*
- Baseline fuel emissions, combustion (tank-to-wheel) for total fleet, internal combustion engine vehicles alone*, and alternative/electric vehicles alone*
- Percent gasoline vs. diesel in liquid fuel mix
- Composition of gasoline and diesel fuel mix
- Criteria pollutant emissions per mile traveled

Public Health Impacts Related to Transportation Emissions

- Health incidences per ton of pollutant
- Health costs per ton of pollutant

Building Energy Emissions

- Electricity generation emissions (lbs/kWh)
- Natural gas combustion emissions (lbs/therm)
- Electricity generation emissions in horizon years (lbs/kWh)
- Natural gas combustion emissions in horizon years (lbs/therm)

Residential Building Energy Use & Price

- Baseline average annual energy use per unit for base/existing population
- Annual energy use by building type
- Housing unit replacement rate for base/existing housing stock
- Upgrade efficiency reduction factor ‘A’ for base/existing housing stock
- New efficiency reduction factor ‘B’ for replacement units of base/existing housing stock
- Upgrade efficiency reduction factor ‘C’ for replacement units of base/existing housing stock
- New efficiency factor ‘D’ for new units of the growth increment
- Upgrade efficiency factor ‘E’ for new units of the growth increment
- Baseline residential electricity price
- Baseline residential gas price
- Residential electricity price in horizon years
- Residential gas price in horizon years

Commercial Building Energy Use & Price

- Non-farm job proportion by floorspace-type category
- Floorspace per employee by category for each LDC
- Commercial space replacement rate for base/existing housing stock
- Baseline average annual energy use per square foot for base/existing commercial space
- Annual baseline energy use for new commercial space
- Replacement rate for base/existing commercial space
- Upgrade efficiency reduction factor for base/existing commercial space
- New efficiency reduction factor for replacement commercial space
- Upgrade efficiency reduction factor for replacement commercial space
- New efficiency factor for new floorspace of the growth increment
- Upgrade efficiency factor for new floorspace of the growth increment
- Baseline commercial electricity price
- Baseline commercial gas price
- Commercial electricity and gas price in horizon years

Residential Building Water Use

- Baseline per capita indoor water demand by building type
- Baseline per-unit outdoor water demand by building type
- New residential water efficiency (% reduction from 2005)
- Baseline water price ($/acre foot)
- Water price in horizon years ($/acre foot)

Residential Water-Related Energy Use and Emissions

- Average water energy proxy (electricity required per million gallons water used)