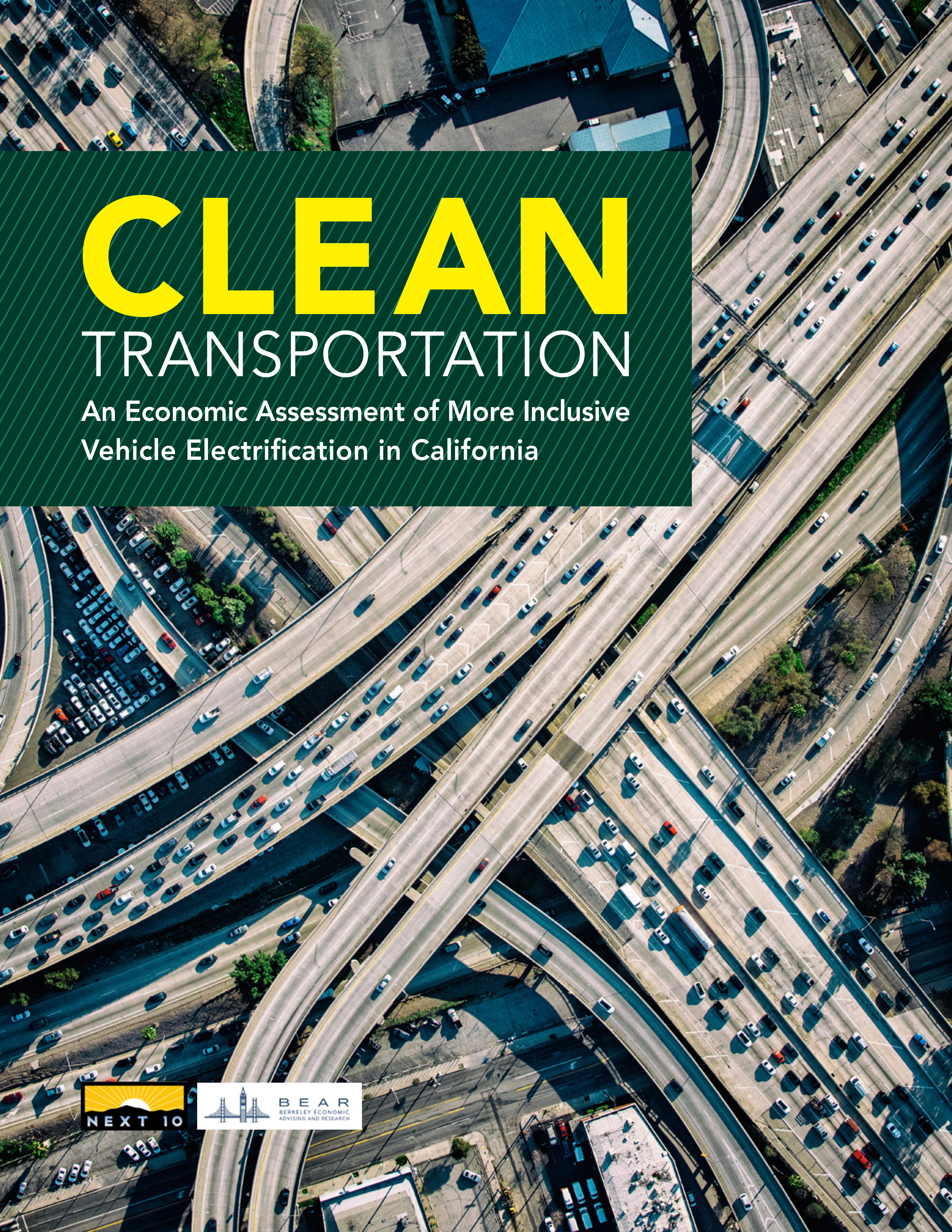

CLEAN TRANSPORTATION

An Economic Assessment of More Inclusive Vehicle Electrification in California

NEXT 10

BEAR
BERKELEY ECONOMIC ADVISING AND RESEARCH

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NEXT 10 is an independent nonpartisan organization that educates, engages and empowers Californians to improve the state's future.

Next 10 is focused on innovation and the intersection between the economy, the environment, and quality of life issues for all Californians. We provide critical data to help inform the state's efforts to grow the economy and reduce greenhouse gas emissions. Next 10 was founded in 2003 by businessman and philanthropist F. Noel Perry.

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Executive Summary

California's transportation sector is the largest contributor of greenhouse gas emissions in the state, accounting for 41 percent of statewide emissions.[1] Electrification of the light vehicle fleet is an essential component of the state's ambitious plans to reduce global warming pollution. While adoption of plug-in electric vehicles (PEVs) has been relatively gradual and unequally distributed across the population, overall adoption is likely to accelerate as prices continue to drop, technology continues to improve, and more mass market vehicles become competitive. To promote more inclusive access to these innovative vehicle technologies, the state is considering more targeted incentives.

To help elucidate some of the potential impacts and benefits of broader PEV adoption, this study assesses the economic implications of the projected increase in electric vehicle use with a long-term economic forecasting model. Four scenarios were considered in order to illustrate the consequences of different pathways for large-scale electrification of the light vehicle fleet (Table ES.1), with two key factors informing the variations between each scenario: (1) electric vehicle adoption patterns and (2) Incremental Vehicle Costs (IVC)—or the incremental cost of purchasing a higher-priced PEV instead of an otherwise comparable conventional internal combustion engine (ICE) vehicle. The adoption patterns vary among the scenarios, with the Baseline assuming current adoption patterns—meaning greater adoption at higher-income levels—while the other scenarios assume the adoption patterns converge by 2030 or 2050.

The study found that vehicle electrification under the scenario with relatively more conservative cost assumptions would confer significant economic benefits by both 2030 and 2050—resulting in increases to Gross State Product (GSP), employment, real household incomes, and state revenue. These results indicate that wider and more rapid PEV adoption will benefit most Californians—whether they buy a PEV or not—by stimulating the overall economy and reducing harmful criteria pollution. The study also finds that promoting PEV adoption in lower-income communities improves both economic and health benefits to them without significantly reducing benefits to others.

KEY FINDINGS INCLUDE:

- **Light-duty vehicle electrification** can be a potent catalyst for California's economic growth between 2020 and 2030, stimulating job growth directly and indirectly across the economy.
  - By 2030, vehicle electrification will increase California's GSP by between $82 billion to $142 billion, depending on the scenario.
  - Real income is projected to increase substantially—ranging from between $311 billion to $357 billion in 2030, depending on the scenario.
  - Study authors calculated an estimated increase of 394,000 new jobs in 2030 under the relatively more conservative scenario (LTES)—and more than half a million new jobs under the scenarios that account

1 2019 California Green Innovation Index. Next 10. October 8, 2019. Available at: https://www.next10.org/publications/2019-gii

for declining costs and increasing availability of PEVs. These do not include the substantial employment gains that exceed direct job creation.

   » This overall economic expansion has significant fiscal benefits–generating billions in additional revenue per year from existing tax instruments.

- Looking out to 2050, **the economic benefits increase by seven to eight times,** depending on the scenario, over those in 2030 as the growth dividends from more efficient mobility are amplified.
   » Money that would otherwise go to out-of-state energy companies is instead spent on largely in-state goods and services. Even in the conservative LTES scenario, vehicle electrification increases California's GSP by about five percent by 2050.
   » In the scenarios (Innovation and Equity) that reflect more realistic vehicle cost reductions, the gains are almost twice as large.
- **Individual Californians gain from increased economic growth** associated with fuel cost savings due to vehicle electrification, whether they buy a new car or not.
- Because households and enterprises spend their fuel savings primarily on services, employment and income benefits are proportionately higher among Disadvantaged Communities (DACs).
   » DACs will experience relatively higher job growth and larger per capita economic benefits from reduced mortality.
   » Air pollution reductions from large-scale electric vehicle adoption also benefit DAC households more than higher-income groups due to decreased health costs.

POLICY CONSIDERATIONS

- Most of the benefits of PEV adoption occur regardless of who adopts the vehicles, but if policies can accelerate adoption in DACs, these groups will benefit more from direct savings and local pollution reduction, and California will come much closer to achieving its long-term pollution reduction goals.
- Creating a market to incubate the next generation of fuel-efficient vehicles could promote job growth across California's economy while capturing national and global market opportunities for technology development.
- Benefits to GSP and income dwarf the amounts accruing to other policies, such as California's cap-and-trade program and the budgets thus far committed to clean vehicle incentive programs. Under any of the alternative scenarios considered, increased vehicle fleet electrification could be very lucrative for the state.
- While the current federal administration's approach toward California's authority to regulate vehicles provides some uncertainty, the fiscal authority to offer economic incentives is much more secure. The state could consider pursuing and expanding incentives more aggressively to optimize net benefits, such as reduced GHG emissions and a variety of economic and health co-benefits that are discussed in this study.

ANALYSIS APPROACH & RESULTS

To review the initial evidence, the study begins with a summary of the latest research on emerging PEV technology. A set of scenarios (detailed in Table ES.1) are established that reflect the current policy dialogue on how to advance California vehicle electrification, and in particular, how to do so more inclusively. Included in the analysis is an evaluation of the challenges for Disadvantaged Communities (DACs) to adopt and benefit from innovative vehicle technologies that have heretofore been out of reach. A more detailed description of scenario assumptions is provided below, including visual representations of adoption patterns that drive each

TABLE ES.1 Scenarios Evaluated in the Present Study

	SCENARIO	DESCRIPTION	ADOPTION	INCREMENTAL VEHICLE COST
1	**Baseline**	A reference Scenario with existing policies in force to 2050. Baseline policies are complemented by revised adoption and use cost estimates commissioned by CEC from E3. Vehicle technology costs are assumed to remain constant at current levels.	Constant adoption shares among income groups	High
2	**LTES**	Incorporates E3 technology cost estimates for vehicles, declining over time.	Equal shares by 2050	Medium
3	**Innovation**	LTES policies to 2030 and 2050, taking account of more recent vehicle technology cost estimates.[2]	Equal shares by 2050	Low
4	**Equity**	The LTES scenario with PEV purchase shares equalizing across California income groups by 2030.	Equal shares by 2030	Low

Source: Authors' Analysis

scenario (Figure ES.1). Results for the macroeconomic assessment and DAC assessment are then presented for the two milestone years 2030 and 2050.

The scenarios analyzed differentiate the pattern of PEV adoption over time, using the state's aggregate GHG reduction commitment as the reference. This study assumes that the light-duty vehicle fleet will reduce its aggregate GHG emissions 40 percent below the 1990 level by 2030 and 80 percent below the same level by 2050. It is also assumed that these goals are achieved with a fleet that blends four categories of vehicles: ICE, PHEV, BEV, and HFC. The adoption scenarios do not mandate full electrification by 2050, but assume BEV and HFC vehicles have zero emissions (including electric power source emissions) and PHEVs have half of the emissions of ICE vehicles. Finally, ICE vehicles are assumed to deliver efficiency improvements as mandated by the state over the same period.

Having specified the composition of the aggregate vehicle fleet, what remains is to determine who owns the vehicle types and what are their comparative costs. As already indicated, IVC profiles for PEVs are evaluated that are relatively High (Baseline), Medium (LTES), and Low (Innovation and Equity). In terms of ownership, the first three scenarios assume that the income group shares of the vehicle fleet remain at today's levels until 2030, but then converge to the same shares of vehicle types as the aggregate fleet by 2050. In the Equity scenario, it is assumed that all income groups converge by 2030. In other words, the incremental costs and benefits of the aggregate fleet are shared equally by all households by 2050 in the first three scenarios, but 20 years earlier in the Equity scenario.

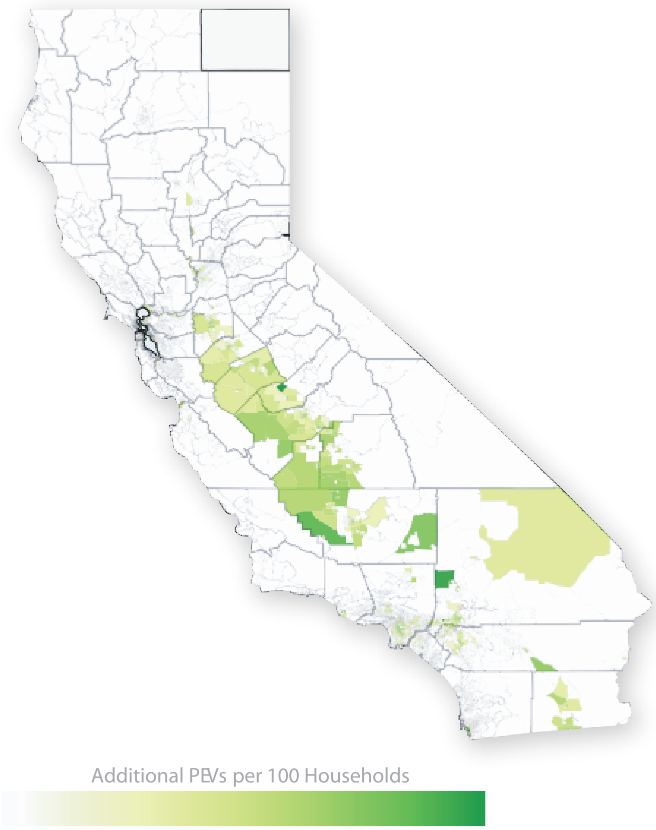
This assessment does not explicitly model vehicle consumer behavior, only the consequences of alternative adoption patterns that can be envisioned by policy makers. The goal of this study is to illustrate economic benefits of these alternative adoption pathways across the state as a whole in an effort to strengthen evidence supporting the choice of policy objectives—not to prescribe interventions that would induce a given adoption pathway.

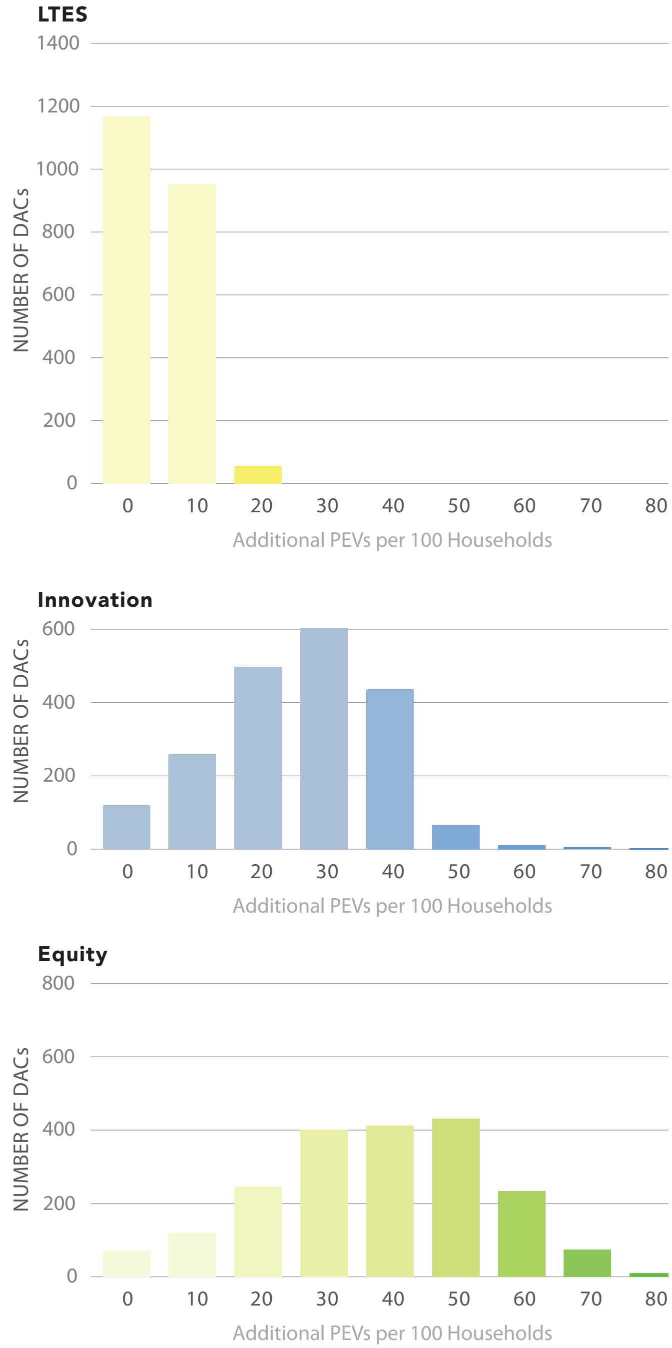
Macroeconomic Impacts in 2030

The study finds that vehicle electrification under LTES cost assumptions would confer significant economic benefits from direct and indirect demand stimulus, and that these combine to increase Gross State Product (GSP), employment, real household incomes, and state revenue. The Innovation scenario incorporates more recent and significantly lower vehicle cost estimates from the International

2 Lutsey, Nic, et. al. "Update on electric vehicle costs in the United States through 2030." The International Council on Clean Transportation. April 2, 2019. Available at: https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf

FIG ES.1 PEV Adoption Patterns in DACs by Scenario, 2030





Source: Authors' Analysis

Council on Clean Transportation[3] and significantly improves the aggregate economic stimulus. Finally, more equitable vehicle adoption pathways yield essentially the same overall benefit, but the composition differs in important ways. Once again, it should be emphasized that the threefold stimulus from accelerated PEV deployment creates growth and jobs broadly across the economy, with many Californians benefitting whether they by a PEV or not.

Percent changes are useful in comparing the relative impacts between different scenarios, but do not give a clear idea to the magnitude of these effects. Indeed, the fiscal dimensions of California climate policy has great significance for many public programs and private parties who bear costs and benefits of policies.

Table ES.3 presents the estimated macroeconomic impacts in inflation-adjusted 2016 dollars.

These results illustrate the size of the impacts with GSP increasing some $82 to $142 billion in 2030, de-

3 Lutsey, Nic, et. al. "Update on electric vehicle costs in the United States through 2030." The International Council on Clean Transportation. April 2, 2019. Available at: https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf

pending on the scenario. Real income is projected to increase substantially—ranging between $311 billion to $357 billion in 2030, depending on the scenario. Perhaps the most arresting feature of these numbers is how they dwarf the amounts accruing to (e.g.) California's cap-and-trade mechanism, as well as the budgets thus far committed to clean vehicle incentive programs. If more vehicle fleet electrification can deliver even a fraction of the estimated revenue for any of the alternative scenarios considered, it could be very lucrative for the state. The disparity in program and impact numbers is hardly surprising, even before considering multiplier effects. Energy program revenues are based on marginal fuel and other user taxes, while large-scale PEV adoption recycles household and enterprise savings from cutting back between 40 to 80 percent of what Californians traditionally spend on gas for vehicles.[4]

This finding points to another important policy issue for California—reliance on incentives over standards. Currently, there are persistent uncertainties regarding the state's authority to regulate vehicles and other energy use technologies. Fiscal authority to offer economic incentives is much more secure, and our results suggest the state could pursue this much more aggressively, reaping net benefits in terms GHG emissions and a variety of economic and health co-benefits discussed in this study. The scope for incentives can also be significantly expanded, to include purchaser prices, financing, vehicle sharing, dealer and manufacturer incentives, infrastructure (e.g. charging) and component technology subsidies.

With regard to jobs, the study found an estimated increase of 394,000 new jobs in 2030 with higher-cost PEVs, to over half a million new jobs with more recent, lower vehicle purchase and operating cost projections. It should be noted that overall employment gains significantly exceed direct job creation that can be expected from increased PEV sales.

TABLE ES.2 Macroeconomic Impacts in 2030 - Percentages (Change from Baseline in 2030)

	LTES	INNOVATION	EQUITY
Gross State Product ($B)	1.48%	2.55%	2.54%
Real Output	2.18%	3.10%	3.08%
Employment	1.44%	1.95%	1.94%
Real Income	2.92%	3.99%	4.16%
In State Revenue	1.45%	2.51%	2.50%

Source: Authors' Analysis

TABLE ES.3 Macroeconomic Impacts in 2030 - Absolute Levels (Difference from Baseline in 2030; 2016 $ Billions Unless Noted)

	LTES	INNOVATION	EQUITY
Gross State Product ($B)	82	142	141
Real Output	179	256	254
Employment	394	532	530
Real Income	311	351	357
In State Revenue	4	7	7

Source: Authors' Analysis

Finally, it should also be noted that overall economic expansion has significant fiscal benefits, generating billions in additional revenue per year from existing tax instruments. Much larger than California's anticipated cap-and-trade revenue, it is a reminder that pro-growth aspects of new vehicle adoption policy can yield substantial new resources for reinvestment in public goods and services.

4 Annual gasoline demand in California is currently about 15 billion gallons, the retail value of which is about $60 billion.

Macroeconomic Impacts in 2050

Extending this analysis to 2050 significantly amplifies the growth dividends associated with more efficient mobility (Tables ES.4 and ES.5). Like interest, energy and other use savings from more efficient technology compound over time, where the multiplier in this case comes from the expenditures diverted from (largely imported) energy fuels to in-state goods and (predominately) services. The result is that extending the scenario horizon threefold (from 10 years in the future to 30 years) increases economic benefits (real GSP) by seven to eight times, depending on the scenario. Even in the relatively conservative LTES scenario, vehicle electrification increases California GSP by about five percent by 2050, assuming the state meets its adoption goals under a relatively high-cost scenario. With a greater reduction in vehicle costs, the gains are almost twice as large. Because adoption patterns between 2030 and 2050 are essentially the same for the Innovation and Equity scenarios, they differ little by the final year. Having said this, it should be emphasized that these two scenarios have very different effects on economic inequality.

The macroeconomic drivers of these three scenarios are simply described. As was already established by in the independent assessment of CEC's Long-Term Energy Strategy (LTES), investments in new and more efficient clean energy provide significant net stimulus to the California economy.[5] Decomposing the PEV component of this in the LTES scenario shows how important vehicle electrification is to statewide efficiency gains and growth. When more recent estimated improvements in vehicle cost effectiveness are taken into account with the Innovation scenario, the growth stimulus is even greater. Finally, promoting PEV adoption among lower-income households distributes these household economic benefits more inclusively.

TABLE ES.4 Macroeconomic Impacts in 2050 - Percentages (Change from Baseline in 2050)

	LTES	INNOVATION	EQUITY
Gross State Product ($B)	4.94%	9.24%	9.22%
Real Output	6.00%	10.51%	10.48%
Employment	2.86%	4.03%	4.02%
Real Income	7.80%	12.74%	12.81%
In State Revenue	4.70%	8.81%	8.79%

Source: Authors' Analysis

TABLE ES.5 Macroeconomic Impacts in 2050 - Absolute Levels (Difference from Baseline in 2050; 2016 $ Billions Unless Noted)

	LTES	INNOVATION	EQUITY
Gross State Product ($B)	614	1,150	1,147
Real Output	1118	1,956	1,952
Employment (,000)	1290	1,816	1,812
Real Income	1,216	1,489	1,494
In State Revenue	29	55	54

Source: Authors' Analysis

HOUSEHOLD IMPACTS BY INCOME GROUP

To assess prospects for inclusive vehicle adoption, the BEAR model—which has the ability to forecast results for each state income tax bracket—was used to examine scenario impacts across different California income groups. Given that the benefits from transitioning to electric and other zero-emission vehicles will not be

5 Roland-Host, D., D. Behnke, S. Evans, C. H. Springer, S. Heft-Neal. Senate Bill 350 Study, Volume VIII: Economic Impact Analysis. California State Senate, 2016.

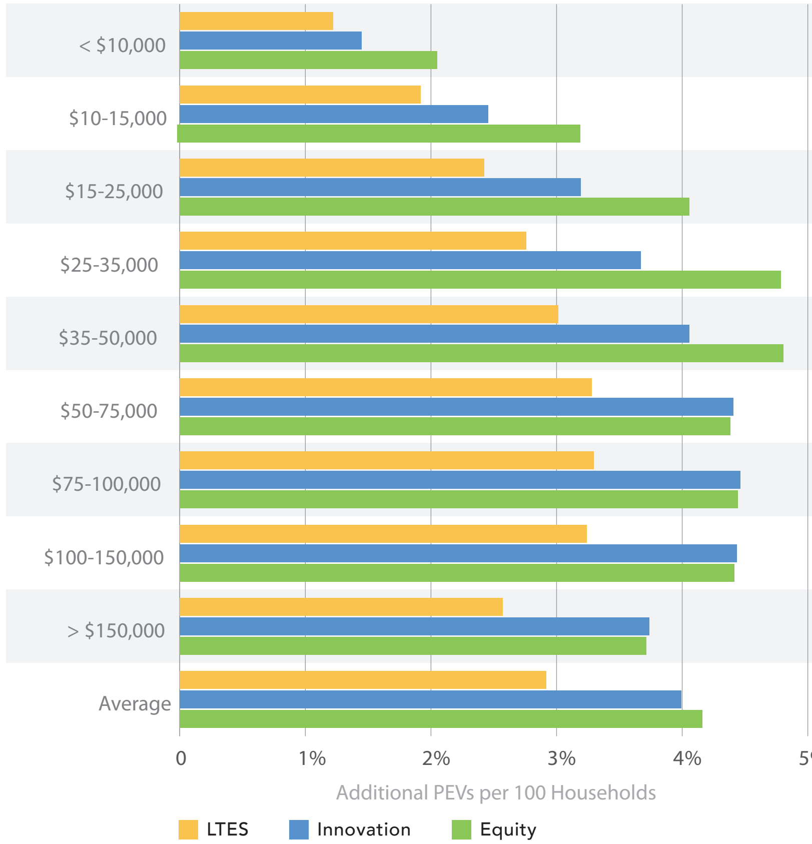
uniformly distributed across the population, this feature of the model is particularly relevant. The results for income impacts by decile are illustrated in Figure ES.2. Here the essential macroeconomic drivers of vehicle electrification can be seen—both in terms of aggregate income growth and its distribution. Simply put, more efficient vehicles confer income benefits on their owners, and these propagate across multiplier linkages to the rest of the state economy. Even when lower-income households capture larger benefits from accelerated adoption rates, these indirect linkages protect most of the gains for higher-income groups.

The LTES scenario assumes the state would progress toward uniform PEV adoption by 2050. The Innovation scenario adhered to the same adoption pathway but offered greater PEV owner savings via more optimistic vehicle cost trajectories. Finally, the Equity scenario shifted PEV purchasing to achieve equal ownership rates across income groups by 2030, meaning the same overall PEV deployment, but more rapid adoption among lower-income groups. The primary difference between these scenarios was the consequent distribution of PEV purchase costs and use savings. The economy and all income groups gained from lower cost vehicle deployment (LTES) and gained more when costs were even lower (Innovation). When lower-income groups experienced more rapid adoption, their gains were even larger than those of higher-income groups, exactly as would be expected.

Less obvious, but very welcome for policy makers, is the finding that higher-income groups would be nearly unaffected by the redistribution of vehicles. This is because, while fewer people may benefit directly from PEV ownership, many more can benefit indirectly from adoption by others, via emission reductions and the economic spillovers from an expanding technology sector.

Any discussion of the economic impacts from large-scale technology adoption also needs to take account of three component impacts: investment in technology production, technology purchasing, and more indirect technology adoption costs/benefits. The first, like building and operating an automobile factory, represents so-called "shovel-ready" investment and is usually an unambiguous economic stimulus. Technology purchase and use costs can have mixed effects on the economy, depending on their so-called opportunity cost. In other words, technology adoption will stimulate the economy if it leads to higher productivity, lower resource costs, or both. If it reduces productivity (e.g. online gaming or shopping during working hours) or increases resource costs, it will be detrimental to economic growth.

FIG ES.2 Household Real Income Changes by Tax Bracket (Percent Change from Baseline Scenario in 2030)



Source: Authors' Analysis

But it is worth noting that, as with the example of Tesla, every time California establishes standards or incentives for adoption of new technology, it creates an incubator the size of the world's fifth-largest economy. Firms know that establishing marketable innovations here can prepare them for global export competitiveness. All of this underscores a central tenet of California's knowledge-intensive growth model—induced growth from technology innovation benefits the overall economy, rewarding even those people who neither develop nor adopt it. For PEVs, this conclusion applies with comparable force to economic and environmental benefits, although PEVs in lower-income communities might displace less efficient vehicles, amplifying these benefits.

DISADVANTAGED COMMUNITY RESULTS

Disadvantaged Communities (DACs), comprised mainly of households in the lower quartile of California incomes and facing higher-than-average pollution burdens, are a primary target for the state's emission mitigation and economic stimulus efforts. From the lower-income perspective, the most important finding of this assessment is that large-scale California vehicle electrification benefits these groups regardless of which patterns of adoption are analyzed. As long as the state accelerates PEV deployment, the savings from this will expand service-intensive household demand, creating jobs across the economy that are more likely to benefit lower-wage, less-skilled workers. It should also be emphasized that these multiplier benefits may not be directly observable as links to higher-income groups adopting efficient vehicles, yet the indirect expenditure linkages are inexorable. Of course, it would also be desirable for lower-income communities to enjoy the direct efficiency and local pollution benefits of PEVs, but these impacts are additional to the overall job-intensive stimulus resulting from expansion of a more fuel-efficient light vehicle fleet. These indirect employment gains are also far greater than direct income and job creation from the PEV sector itself. These comparisons are summarized in Table ES.6 for 2030. Noting first that DACs comprise 25 percent of the California population, this group's job growth significantly exceeds this share (36%) in all scenarios.

TABLE ES.6 Macroeconomic Impacts of PEV Deployment in 2030

IMPACT	SCENARIO	DAC_ SHARE	NONDAC_ SHARE
Jobs	LTES	36%	64%
	Innovation	36%	64%
	Equity	36%	64%
PEVs	LTES	11%	89%
	Innovation	40%	60%
	Equity	45%	55%
Avoided Health Costs	LTES	33%	67%
	Innovation	34%	66%
	Equity	34%	66%

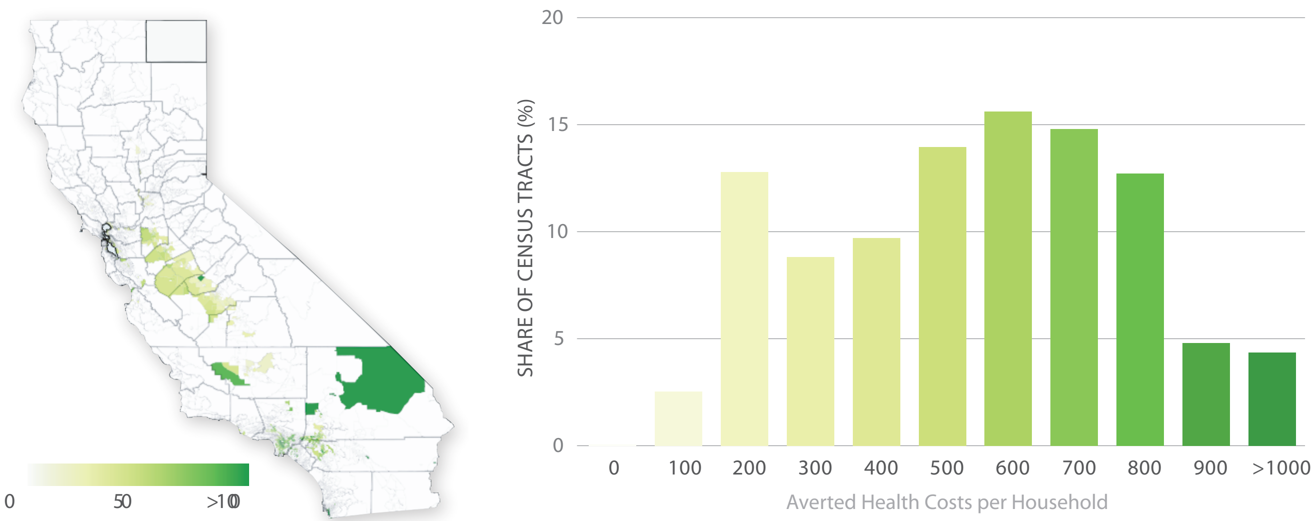
Source: Authors' Analysis

DAC Job Impacts

Job growth statewide is driven by new jobs in service industries and these sectors happen to be sectors that disproportionately employ DAC workers. As Los Angeles County and the Central Valley comprise 75 percent of the disadvantaged communities in the state, these two regions were analyzed for this study. Approximately 25 percent of the state population lives in a DAC.

- In Los Angeles County, 45 percent of the population lives in a DAC community and DAC workers are 55 percent more likely to be employed in service industries. In the Innovation Scenario, more than half of the 161,000 forecasted jobs by 2030 in that county in are forecast to be created in DACs.
- More than 32,000 of the 59,000 jobs created in the Central Valley by 2030 in the Innovation Scenario are forecast to be created in DACs.
- By 2050, the Innovation Scenario gives rise to 1.812 million additional jobs across the state, with 36 percent generated for DAC households.
    - » Los Angeles County (192 jobs created per DAC) and the Central Valley (216 jobs created per DAC) enjoy substantial incremental employment benefits.

FIG ES.3 Estimated DAC Health Cost Savings, Equity Scenario, 2030



Source: Authors' Analysis

DAC Health Impacts

In terms of averted health costs from reduced vehicular criteria pollution, DACs again enjoy relatively greater benefits that Non-DAC communities, regardless of the which of the three PEV adoption patterns prevails. Study estimates represent health benefits associated with reductions in criteria pollutant (NOx, SOx, and PM2.5) emissions in the vehicle sector alone but do not quantify many of the other expected benefits that are known to be substantial. However, assuming uniform statewide emission reductions, **these benefits are higher for households in disadvantaged communities.** Moreover, it is likely underestimating the total benefits to DACs of these policies as cannot fully account for the potential benefits to DACs because they are often located closer to high-traffic roads and highways.[6]

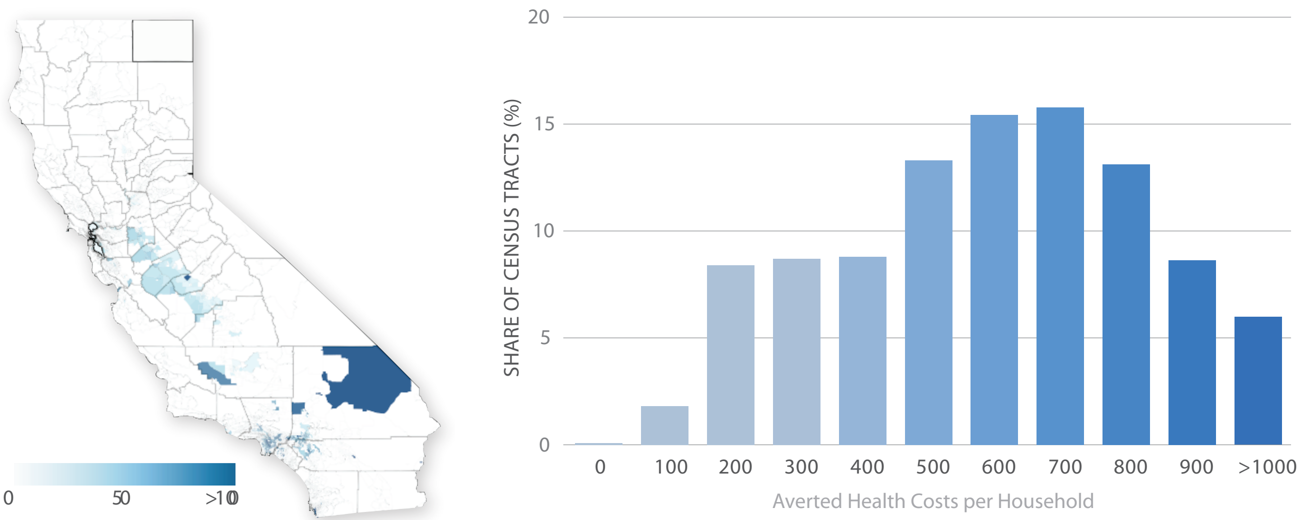
- Under the Equity Scenario, the economic value of health benefits from reductions in criteria pollutants in the energy and fuel sector will be $2.0 billion by 2030—$800 million from averted mortality and $1.2 billion from averted medical costs.
- The benefits are higher for DAC households than non-DAC households—with $581 averted per DAC household and $494 averted per non-DAC household—and the savings represent a greater proportion of household income for DACs.

Because DAC households have lower incomes, their economic gains are even more dramatic in relative terms. However, more targeted policies could produce even larger gains. By 2030, forecasts from this study indicate that health benefits across California DACs could be substantial, even in the more technology-pessimistic LTES scenario (Figure ES.5), but even greater with higher rates of PEV innovation (Figure ES.4) and lower-income household vehicle adoption (Figure ES.3).

To summarize—for all scenarios evaluated, compared to the rest of the state's population, Disadvantaged Communities (DACs) will experience higher job growth and larger per capita economic benefits from reduced mortality and morbidity than in the baseline case.

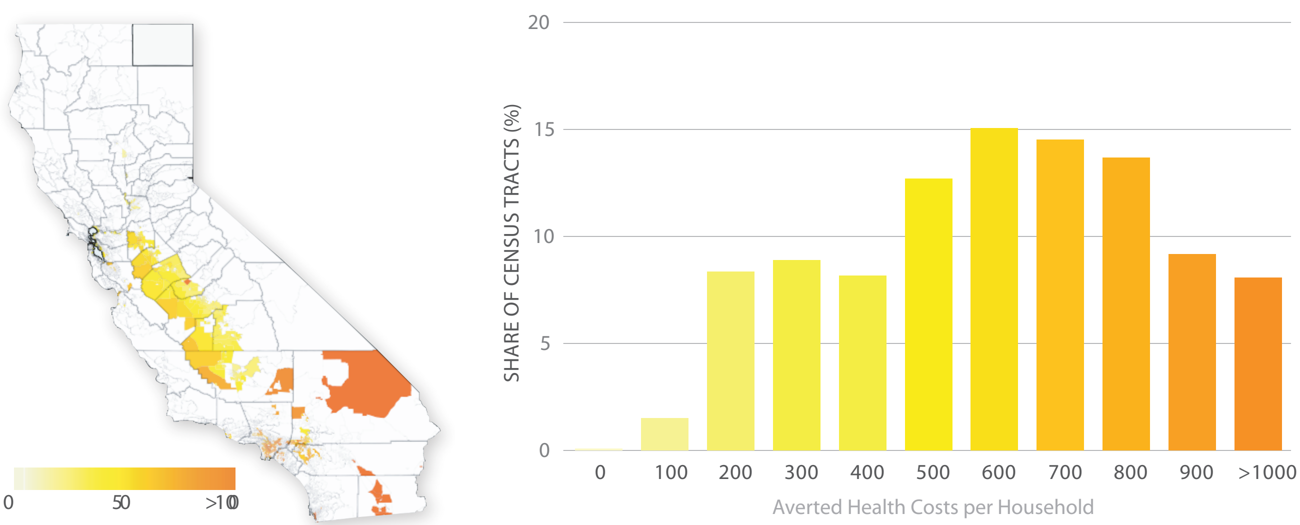
6 CHAPTER 10: Climate Adaptation and Resiliency, section 6: in "Increasing Climate Resilience in Disadvantaged Communities" includes a detailed description of how DAC exposure to poor air quality correlates with proximity to transportation networks. Available at: http://www.energy.ca.gov/2017_energypolicy/

FIG ES.4 Estimated DAC Health Cost Savings, Innovation Scenario, 2030



Source: Authors' Analysis

FIG ES.5 Estimated DAC Health Cost Savings, LTES Scenario, 2030



Source: Authors' Analysis

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