Macroeconomic Analysis of Clean Vehicle Scenarios for Colorado

Prepared for Environmental Entrepreneurs (E2)

June 12, 2018

AUTHORS

Avi Allison
Jamie Hall

Synapse Energy Economics, Inc.

485 Massachusetts Avenue, Suite 2
Cambridge, Massachusetts 02139

617.661.3248 | www.synapse-energy.com

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EXECUTIVE SUMMARY

In recent years, Colorado has been investigating options for reducing in-state motor vehicle emissions. This topic has become particularly pressing since the U.S. Environmental Protection Agency (EPA) announced its plan to weaken federal greenhouse gas (GHG) regulations for light-duty vehicles. One possibility under consideration for Colorado is the adoption of state advanced clean car standards that would cover passenger vehicle GHG tailpipe emissions and establish zero emission vehicle (ZEV) standards.

Synapse Energy Economics (Synapse) analyzed the macroeconomic impacts of a Clean Vehicles scenario in which Colorado enacts more aggressive GHG emission standards and pursues increased electric vehicle (EV) penetration, relative to a baseline in which GHG standards remain constant at federally set 2020 levels and EV adoption remains low. We used the IMPLAN economic input-output model to evaluate impacts on employment and gross domestic product (GDP) over the period from 2020 through 2035. Our analysis accounted for effects associated with the increased up-front costs of lower-emitting vehicles, reduced gasoline expenditures, and increased spending on electricity.

We found that the pursuit of a cleaner, light-duty passenger vehicle fleet is likely to result in small but positive long-term macroeconomic impacts in Colorado. We estimate average annual increases of approximately $72 million in GDP and 1,700 jobs under the Clean Vehicles scenario. While these impacts are small in the context of the nearly $350 billion total Colorado economy, the net positive impacts of cleaner vehicles are expected to grow over time as fuel savings accumulate and EVs become cheaper. Our analysis indicates that Colorado can achieve the health and environmental benefits of vehicle emission reductions while continuing to strengthen its economy.

1. INTRODUCTION

Colorado has recently been exploring strategies and policies for advancing lower-emitting vehicles. In January 2018, a group of state agencies released a Colorado Electric Vehicle Plan designed to support the development of electric vehicle (EV) infrastructure within Colorado.[1] Following the U.S. Environmental Protection Agency's (EPA) and the National Highway Traffic and Safety Administration's (NHTSA) announcement of their intention to roll back federal greenhouse gas (GHG) emission and fuel economy standards for cars and light trucks, Governor Hickenlooper announced his support for keeping the existing standards strong.[2] To that end, the Colorado Air Quality Control Commission and the Department of Public Health & Environment have been holding public hearings on the impacts of adopting California's GHG standards and Zero Emission Vehicle (ZEV) mandate.[3]

Previous studies have analyzed the potential emission and cost-benefit impacts of Colorado adopting clean vehicle standards.[4] This report builds off those prior analyses to evaluate the macroeconomic impacts associated with Colorado pursuing a more fuel efficient and lower-emitting light-duty fleet. We assess how statewide employment and gross domestic product (GDP) may change under a Clean Vehicles scenario in which Colorado adopts more stringent fuel economy standards and aggressively pursues vehicle electrification, relative to a baseline in which Colorado takes no action while federal standards are weakened. We find that over the time period analyzed, 2020 through 2025, adopting state clean car standards is likely to result in small but positive macroeconomic impacts.

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[1] Colorado Electric Vehicle Plan. January 2018. Available at https://www.colorado.gov/governor/sites/default/files/colorado_electric_vehicle_plan_-_january_2018.pdf.

[2] Roberts, M. 2018. "An Outpouring of Support for Cleaner Car Standards, in the Face of Pruitt's Attempted Rollback." Blog post on April 6, 2018. http://blogs.edf.org/climate411/2018/04/06/an-outpouring-of-support-for-clean-car-standards-in-the-face-of-pruitts-attempted-rollback/

[3] Colorado Department of Public Health and Environment. 2018. "Colorado's Efforts to Reduce GHG Emissions," February 15, 2018. P. 15. Available at https://www.colorado.gov/pacific/sites/default/files/021518_GreenhouseGases_presentation.pdf

[4] M.J. Bradley & Associates. 2017. *Electric Vehicle Cost-Benefit Analysis: Plug-in Electric Vehicle Cost-Benefit Analysis: Colorado.* Available at https://mjbradley.com/sites/default/files/CO_PEV_CB_Analysis_FINAL_13apr17.pdf; France, C. 2017. "Advanced Clean Cars and Colorado." Environmental Defense Fund. Available at https://www.colorado.gov/pacific/sites/default/files/111617-CleanCarStds-presentation-EDF-REV.pdf.

2. METHODS AND ASSUMPTIONS

2.1. Methods

We evaluated the macroeconomic impacts resulting from a Clean Vehicles scenario that incorporates two separate but related components: (1) a transition towards more fuel-efficient vehicles and (2) increased penetration of EVs. We used the IMPLAN model to project GDP and employment impacts over the period from 2020 through 2035, relative to a baseline in which fuel economy standards remain constant from 2020 onward and EV penetration remains low. IMPLAN is an economic input-output model that uses historical data to evaluate state-specific impacts from an initial change in economic activity.[5]

We modeled three primary pathways by which the development of lower-emission vehicles impacts the Colorado macroeconomy:

1. **Auto sector investment.** This pathway accounts for the impacts of incremental up-front vehicle costs on the auto sector and its suppliers. This includes both increased purchases of batteries and related EV infrastructure and increased investment in fuel-efficient technologies for gas-powered internal combustion engine (ICE) vehicles. This pathway also accounts for changes in vehicle sales driven by the net compliance costs associated with more efficient vehicles.

2. **Electric sector investment.** This pathway traces economic impacts associated with increased electricity consumption by new EV owners.

3. **Gasoline spending reduction.** This pathway accounts for the impacts of reduced expenditures on gasoline resulting from the combination of a shift from ICEs to EVs and the use of more fuel-efficient ICEs.

Within each of these pathways, we considered three types of economic impacts:

- **Direct impacts.** These are economic effects in sectors immediately impacted by vehicle standards. Examples include changes in employment in the auto manufacturing sector resulting from the need to incorporate additional fuel-saving technologies in future cars.

- **Indirect impacts.** These are changes in employment and GDP within industries that serve as suppliers to the directly affected industries. For example, these include effects on the battery industry and other suppliers to the manufacturers of EVs.

- **Induced impacts.** These are changes in employment and GDP associated with shifts in consumer spending in the broader economy. Induced effects account for the propensity of consumers to re-spend most of their fuel savings resulting from the use of more fuel-efficient vehicles. Induced effects also arise as a result of changes in consumer spending

[5] This study used the 2016 IMPLAN data set for Colorado.

by employees in directly and indirectly impacted industries who have more (or less) disposable income.

Under our modeling framework, every direct impact is offset to at least some degree by an induced impact that works in the opposite direction. If vehicle standards drive decreased spending on gasoline, they result in increased spending on other industries, as consumers re-spend their gas savings elsewhere. Similarly, if increased EV penetration results in increased spending on batteries and electric power plants, consumers have less money left to spend on other industries.

2.2. Key Input Assumptions

Our analysis necessarily relied on a host of assumptions regarding vehicle costs, fuel prices, fuel economy levels, and other relevant parameters. The most important of these inputs are identified below. In general, our assumptions relied heavily on prior analyses conducted by the Environmental Defense Fund (EDF) and M.J. Bradley.[6]

ICE Compliance Costs

ICE compliance costs represent the average, per-vehicle incremental cost of an ICE that meets increasingly stringent GHG standards consistent with California's vehicle standard trajectory, relative to a baseline of a vehicle that complies with the 2020 federal GHG standards. We based our GHG compliance cost assumptions on recent OMEGA modeling conducted by EDF. OMEGA is an EPA tool that estimates technology costs for automobile manufacturers to achieve fleet-wide reductions in GHG emissions.[7]

EDF only conducted OMEGA modeling runs for model years 2020 and 2025, so we linearly interpolated compliance costs for model years 2021-2024, based on incremental fuel economy improvements in those years. Consistent with EDF, we assumed that compliance costs and fuel economy levels hold constant in all years beyond 2025. Table 1 shows our assumed Clean Vehicles scenario ICE compliance costs.

Table 1. Clean Vehicles Scenario ICE Compliance Costs Relative to Baseline of 2020 GHG Standard

Vehicle Type	Units	2021	2022	2023	2024	2025
Cars	2017 $/Vehicle	$0	$458	$610	$774	$937
Light Trucks	2017 $/Vehicle	$0	$717	$930	$1,163	$1,337

[6] M.J. Bradley & Associates. 2017. *Electric Vehicle Cost-Benefit Analysis: Plug-in Electric Vehicle Cost-Benefit Analysis: Colorado*; France, C. "Advanced Clean Cars and Colorado."

[7] See U.S. EPA. Optimization Model for Reducing Emissions of Greenhouse Gases from Automobiles (OMEGA). https://www.epa.gov/regulations-emissions-vehicles-and-engines/optimization-model-reducing-emissions-greenhouse-gases

EV Price Premium

EV price premiums constitute the incremental up-front cost of an EV relative to a standard new ICE vehicle.[8] Our projection of EV price premiums relied primarily on data from the 2016 Draft Technical Assessment Report (TAR) issued as part of EPA's mid-term review of federal GHG standards.[9] Since the Draft TAR was released, projections of EV battery costs have fallen. Therefore, in our Base case we replaced the Draft TAR's estimate of the battery component of the EV price premium with a more recent estimate from Bloomberg New Energy Finance.[10] We also included in-home charger costs from the Draft TAR in our analysis.

Since future EV costs are a critical yet highly uncertain input to our analysis, we also evaluated two sensitivities: a High case in which EV costs follow EPA's conservative and now dated TAR trajectory and a Low case in which battery electric vehicles (BEVs) reach price parity with ICEs by 2025, as numerous recent studies have identified.[11] Figure 1 displays the projected price premiums for BEVs with a range of 100 miles under each of these sensitivities.

[8] We assume that this standard ICE vehicle has fuel economy and cost characteristics associated with compliance with increasingly stringent GHG standards through 2025.

[9] U.S. EPA, U.S. National Highway Traffic Safety Administration, and California Air Resources Board. 2016. *Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025*, Chapter 5. This data is consolidated in a report recently published by Indiana University: Carley, S., D. Duncan, J. D. Graham, S. Siddiki, and N. Zirogiannis. 2017. *A Macroeconomic Study of Federal and State Automotive Regulations*. Pp. 158-162.

[10] Soulopoulos, N. 2017. "When Will Electric Vehicles Be Cheaper Than Conventional Vehicles?" Bloomberg New Energy Finance, April 2017. We note that our resulting Base price premium trajectory is quite similar to that recently published by the International Council for Clean Transportation. "Electric Vehicles: Literature Review of Technology Costs and Carbon Emissions." https://www.theicct.org/sites/default/files/publications/ICCT_LitRvw_EV-tech-costs_201607.pdf.

[11] Soulopoulos, N. 2017.; Morgan Stanley. (2017). "On the Charge." Research Blue Paper. https://www.morganstanley.com/ideas/electric-car-supply-chain; Ark Invest (2017) https://ark-invest.com/research/electric-vehicles (last viewed 5/30/18).

Figure 1. BEV Price Premium Projection (versus ICE)

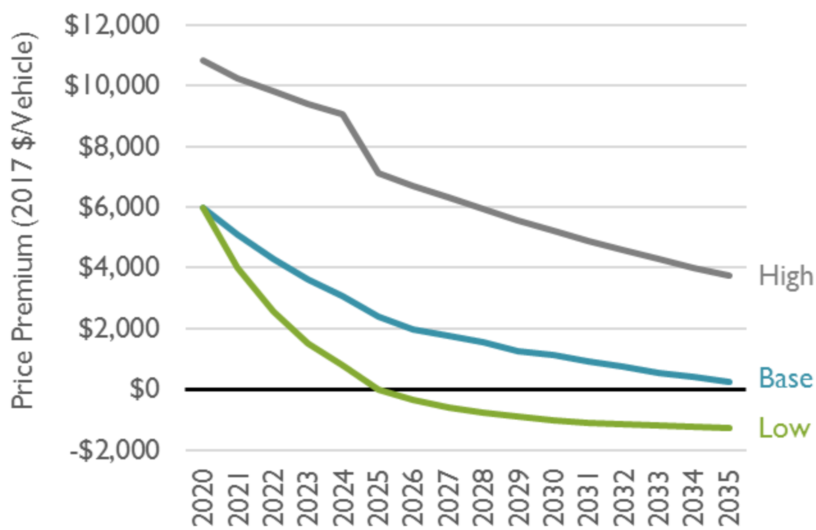
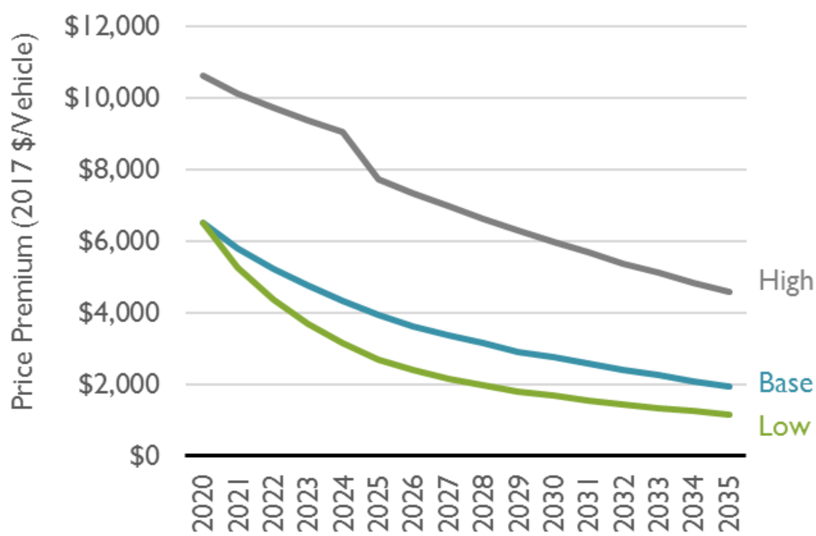


Figure 2 shows our price premium projections for plug-in hybrid electric vehicles (PHEVs) with a 40-mile range under each of our three sensitivities. PHEVs generally have a larger premium than BEVs because they retain the costs associated with a gasoline engine while also adding on the costs of a battery and related EV components.

Figure 2. PHEV Price Premium Projections (versus ICE)



Fuel Economy Levels

Fuel economy assumptions are linked to compliance cost and price premium assumptions. We therefore used ICE fuel economy assumptions consistent with EDF's recent OMEGA modeling for both the baseline fleet and the Clean Vehicles scenario fleet. Those assumptions are identified in Table 2. Beyond 2025, fuel economy levels are assumed to remain constant.

Table 2. Achieved, On-Road ICE Fuel Economy Under GHG Standards and Baseline

Scenario	Vehicle Type	Units	2020	2021	2022	2023	2024	2025
Base	Cars	mpg	36.0	36.0	36.0	36.0	36.0	36.0
Base	Light Trucks	mpg	25.6	25.6	25.6	25.6	25.6	25.6
Clean Vehicles	Cars	mpg	36.0	36.0	40.2	41.6	43.1	44.6
Clean Vehicles	Light Trucks	mpg	25.6	25.6	29.3	30.4	31.6	32.5

Our assumption for the average fuel economy levels of new EVs was based on M.J. Bradley's modeling. Under these assumptions, average EV fuel economy improves steadily over time, from 2.9 miles per kilowatt-hour (kWh) in 2020 to 3.5 miles per kWh in 2035.

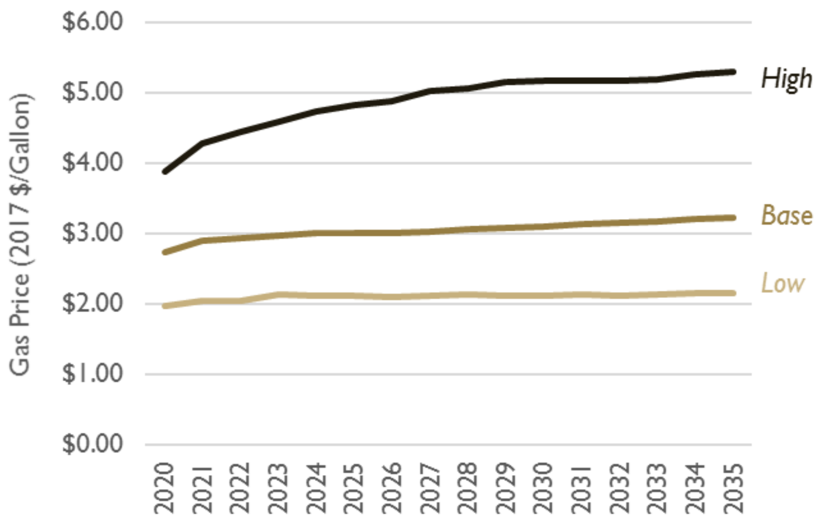
Gasoline Prices

We used gasoline price forecasts rooted in a combination of historical data and projections from the U.S. Energy Information Administration (EIA). Our forecast began with 2017 average annual Colorado gas prices.[12] For our Base case, we assumed that gas prices would then increase at annual growth rates projected for Colorado's Mountain Region in EIA's Annual Energy Outlook (AEO) 2018 Reference case.[13] We also examined High Gas Price and Low Gas Price sensitivities, in which Colorado's gas price evolves at annual growth rates projected under the AEO 2018 High Oil Price and Low Oil Price cases, respectively. The resulting gas price forecasts are shown in Figure 3.

[12] U.S. EIA. 2018. Weekly Retail Gasoline and Diesel Prices. https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sco_a.htm. In 2017, Colorado's average annual gas price was $2.43/gallon.

[13] U.S. EIA. 2018. AEO 2018. Table 59.8: Components of Selected Petroleum Product Prices, Mountain Region. https://www.eia.gov/outlooks/aeo/supplement/excel/suptab_59.8.xlsx.

Figure 3. Colorado Retail Motor Gasoline Price Projections



Vehicle Sales and Costs

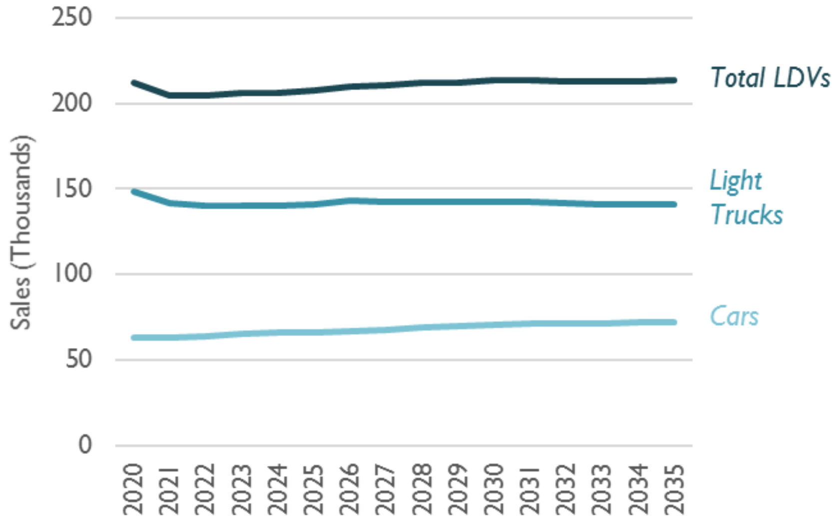
Our analysis of the sales impacts of more aggressive vehicle standards requires an assumption regarding baseline vehicle sales and costs. For baseline sales, we initially relied on 2017 annual new light-duty vehicle (LDV) registration data reported by the Colorado Automobile Dealers Association (CADA).[14] We then assumed that car and light truck sales will increase at annual growth rates projected for Colorado's Mountain Region in the AEO 2018 Reference case.[15]

Figure 4 shows our Base scenario projection of new light-duty vehicle sales. Consistent with CADA data, we assumed that light trucks make up more than two thirds of Colorado light-duty sales.

[14] Colorado Automobile Dealers Association. February 2018 Colorado Auto Outlook. Available at http://www.colorado.auto/sites/default/files/CO%20Jan%2018%20Data.pdf

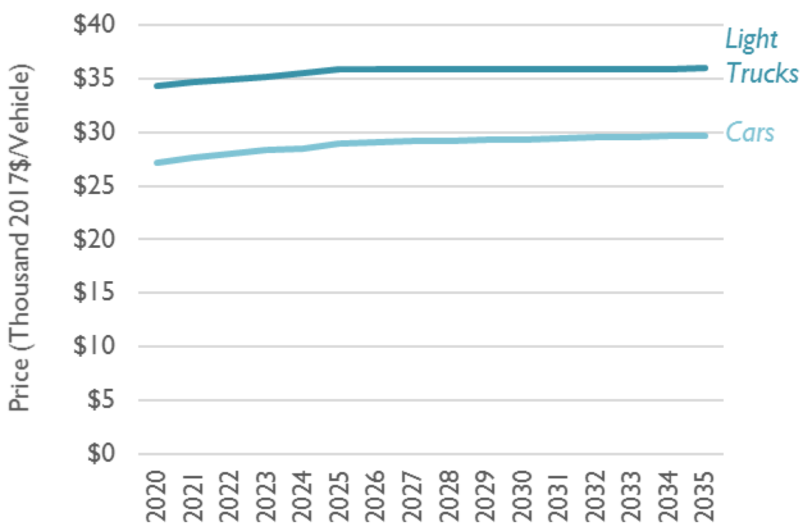
[15] U.S. EIA. 2018. AEO 2018. Table 39.8: Light-Duty Vehicle Sales by Technology Type, Mountain Region. Available at https://www.eia.gov/outlooks/aeo/data/browser/#/?id=48-AEO2018&region=1-8&cases=ref2018

Figure 4. Base New Vehicle Sales



We assumed baseline average new vehicle prices consistent with AEO 2018 projections (see Figure 5).

Figure 5. Base New Vehicle Price



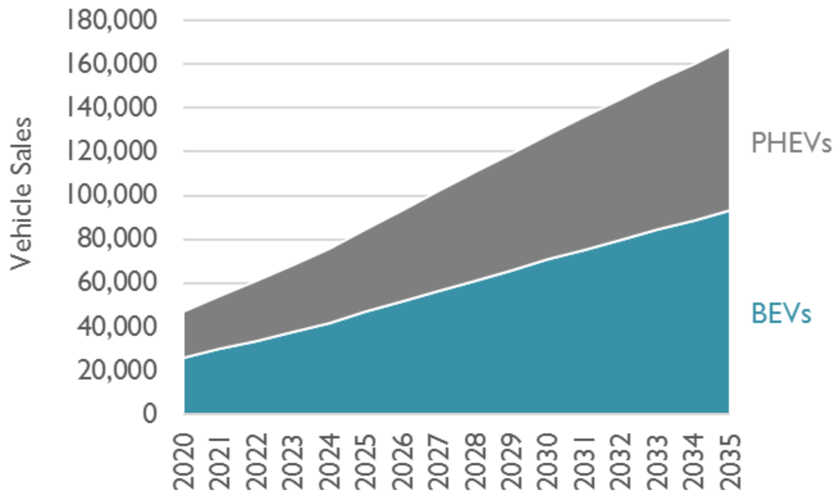
EV Sales

Our Clean Vehicles scenario relied on the High EV Scenario from Colorado's EV Plan.[16] Under this scenario, the aggressive pursuit of EV-friendly policies results in approximately 1 million EVs on the roads of Colorado by 2030. We assumed that the trajectory of increasing sales needed to hit this target

[16] Colorado Electric Vehicle Plan. P. 9.

continues through 2035. Consistent with the M.J. Bradley study, we assumed that 55 percent of new EVs will be BEVs and 45 percent will be PHEVs. Our resulting EV sales forecast is displayed in Figure 6.

Figure 6. Incremental Colorado EV Sales Under Clean Vehicles Scenario



Vehicle Miles Traveled

We based our assumptions for average ICE vehicle miles traveled (VMT) on data provided in EPA's Proposed Determination regarding the federal GHG standards.[17] These VMT estimates account for the percentage of vehicles that remain on the road at each year in the vehicle life span. They also account for consumer response to changes in the operational costs of driving. We used EPA's assumption of a 10 percent price elasticity of demand for VMTs.[18] That is, we assumed that a 10 percent decrease in fuel costs per mile will result in a one percent increase in VMTs. Under these assumptions, average ICEs travel about 8,900 miles per year.

We followed M.J. Bradley's assumption regarding the average number of VMTs driven by EV owners. Under this assumption, the typical EV travels about 8,000 miles per year.

Consumer Financing

The tendency of consumers to finance their new vehicle purchases affects the timing and magnitude of re-spending effects associated with consumers spending more money on vehicles. We based our consumer financing assumptions on recent data reported by Experian.[19] We assumed that 85 percent of

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[17] U.S. EPA. November 2016. Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards Under Midterm Evaluation: Technical Support Document. Pp. 3-7, 3-8.

[18] Id. P. 3-20.

[19] Experian. State of the Automotive Finance Market: A Look at Loans and Leases in Q4 2017. Available at http://www.experian.com/assets/automotive/quarterly-webinars/2017-q4-safm.pdf.

consumers finance their vehicle purchases and that financing happens at an interest rate of five percent and a loan term of five years.

Electric-Sector Costs

Increased EV penetration leads to increased investment in various components of the electric sector, including expenditures associated with additional generation, power plant capacity, and transmission and distribution upgrades. Our assessment of impacts related to electric-sector costs is based on outputs from M.J. Bradley's analysis. We did not undertake any additional electric-sector modeling for the purposes of this study. However, we did map incremental electric-sector costs to custom, resource-specific IMPLAN vectors. We discuss our treatment of each category of electric-sector cost below.

Generation Costs

Our modeling of incremental generation costs began by scaling M.J. Bradley's projections of EV-related increases in generation (in megawatt-hours or MWh) and generation costs to our Clean Vehicles scenario EV sales trajectory. We input these generation impacts into Synapse's Avoided Emissions and Generation Tool (AVERT) to estimate the percentage of increased generation provided by each generation resource type (e.g., natural gas combined cycle, coal).[20] We then multiplied each resource's level of incremental generation by an assumed per-MWh generation cost—including fuel costs and variable operation and maintenance (O&M) costs—taken from AEO 2018.[21] This calculation provided us with resource-specific generation costs that served as the basis for our allocation of total generation costs across resource types for IMPLAN modeling.

Capacity-Related Costs

Our modeling of capacity costs began by scaling M.J. Bradley's projections of EV-related increases in capacity (in megawatts) and capacity costs to our Clean Vehicles scenario EV sales trajectory. We allocated incremental capacity across generation resource types using AEO 2018 projections of the percentage of new capacity coming from each resource type in each year in the Colorado region and AEO 2018 resource-specific projections of construction and fixed O&M costs.[22]

Transmission and Distribution Costs

We scaled M.J. Bradley's projections of EV-related transmission and distribution costs based on our Clean Vehicles scenario EV sales trajectory.

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[20] AVERT, which Synapse developed for the U.S. Environmental Protection Agency, is a tool that provides rough-cut estimates of generation and emissions impacts of energy efficiency, renewable energy, and EV programs.

[21] U.S. EIA. Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2018. https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf

[22] Ibid.

EV Tax Credits

EVs purchased in Colorado are currently eligible for both federal and state tax credits. However, due to the temporal scope of those tax credits, we did not incorporate any tax credits in our modeling.

At present, the state of Colorado offers a tax credit of up to $5,000 per new EV.[23] However, this tax credit is slated to be phased out entirely by 2022. Because our study period runs from 2020 through 2035, this tax credit has minimal relevance to our modeling. In addition, the citizens of Colorado must ultimately pay for the state tax credit. Thus, while the tax credit may influence the decision to purchase EVs, it is unlikely to have substantial economy-wide spending impacts within Colorado.

Federal EV tax credits offer a potential net benefit to Colorado consumers as a group. While the federal tax credit associated with a Coloradan's purchase of an EV accrues entirely to a Colorado customer, the cost of that credit is spread among all U.S. taxpayers, of which Coloradans represent a small percentage. However, the federal EV tax credit is also set to phase out in the coming years. According to current law, the federal tax credit will be phased out for each manufacturer "in the second quarter following the calendar quarter in which a minimum of 200,000 qualified EVs have been sold by that manufacturer for use in the United States."[24] The two largest sellers of EVs in the United States—Tesla and General Motors—are both expected to hit the 200,000 sales mark in 2018, with Ford and Nissan likely to follow in the early 2020s.[25] Therefore, given our study period, we ignored the federal tax credit as well.

To the extent that federal tax credits extend beyond 2020, these credits would result in improved economic impacts from additional EV sales in Colorado.

3. RESULTS

Our analysis indicates that the combination of more stringent fuel economy standards and increased EV penetration is likely to result in small but positive macroeconomic impacts in Colorado over the long term. Table 3 presents the cumulative direct spending impacts by sector under the Clean Vehicles scenario using our Base input assumptions. We expect that the Clean Vehicles scenario will result in increased spending of more than $10 billion on new vehicles and more than $3 billion on electricity over 2020 through 2035. We also forecast that vehicle owners will save more than $13 billion on gasoline over this time period. Even after accounting for increased electric spending by EV owners, this amounts to nearly $10 billion in total fuel savings within Colorado, or more than $600 million on average per year.

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[23] U.S. Department of Energy. Office of Energy Efficiency and Renewable Energy. Electric Vehicles: Tax Credits and Other Incentives. https://www.energy.gov/eere/electricvehicles/electric-vehicles-tax-credits-and-other-incentives

[24] Ibid.

[25] Federal EV Tax Credit Phase Out Tracker By Automaker. http://evadoption.com/ev-sales/federal-ev-tax-credit-phase-out-tracker-by-automaker/

Table 3. Change in Direct Spending over 2020-2035 for Clean Vehicles Scenario (Base Case)

Spending Category	Spending Change (2017 $Million)
Goods	
Vehicles	$10,325
Generic Consumer Goods	-$568
Energy	
Electricity	$3,342
Gasoline	-$13,020
Total	***$79***

We find that this combination of spending changes results in positive employment and GDP impacts. Our results indicate net average annual increases of 1,724 jobs and $72 million in GDP over the period from 2020 through 2035.

Fuel savings are the key driver of these positive overall results. Fuel savings produce macroeconomic benefits within Colorado because gasoline is more capital- and import-intensive relative to the rest of the Colorado economy. A dollar spent on a generic mix of consumer goods results in nearly three times as many in-state jobs as a dollar spent on gasoline, as shown in Table 4. Thus, when Coloradans save on gasoline and re-spend their savings elsewhere, they generally increase in-state employment and GDP.

Table 4. Macroeconomic Impacts in Colorado per Million Dollars of Sectoral Spending

Spending Category	Employment (Job-Years)	GDP (2017 $Million)
Vehicles	5.3	0.44
Electricity	8.2	0.80
Gasoline	3.7	0.43
Generic Consumer Goods	10.8	0.86

Besides generating net fuel savings, increased EV penetration causes a shift in fuel expenditures from the petroleum sector to the electric sector. This shift results in additional net employment and GDP gains because the electric sector is fundamentally more local than the petroleum sector. While oil is a globally traded commodity, investments in the electric infrastructure that serves Coloradans tend to be concentrated within the state. For that reason, each dollar invested in the electric sector produces more than twice as many jobs as the same dollar spent on gasoline.

The primary downside of clean vehicle policies in Colorado is that the state does not have a large auto manufacturing industry.[26] Clean vehicle policies will likely result in increased expenditures on new

[26] According to IMPLAN data, less than 0.1 percent of spending on the auto manufacturing industry by Coloradans stays in Colorado.

vehicles, but without a large in-state auto industry, Colorado's economy will not reap the money Coloradans spend on new vehicles. However, if Colorado were to further develop a clean vehicle technology industry to accompany its increasing purchases of low-emitting vehicles, the net macroeconomic effects of increased auto sector spending would improve.[27] On balance, we still project that the negative consumer re-spending effects from increased spending on imported vehicles will be outweighed by fuel savings benefits in Colorado.

The macroeconomic benefits of the Clean Vehicles scenario increase over time, due to the combination of dropping EV battery prices and the accumulation of fuel savings from an ever-increasing number of efficient vehicles on the road.[28] These benefits do not incorporate potential societal benefits from associated greenhouse gas emission reductions, criteria emission reductions, or reduced petroleum dependency.

Nonetheless, it is worth noting that the macroeconomic impacts we found are very small in the context of the Colorado economy. The average annual GDP impact of $72 million represents less than three hundredths of one percent of Colorado's current annual GDP of more than $342 billion.[29] Similarly, our average employment impact result amounts to less than one tenth of one percent of total Colorado employment.[30]

Finally, we note that our modeling results are dependent on uncertain input assumptions. For this reason, we tested the sensitivity of our results to differences in the trajectories of two key parameters: EV costs and gas prices. Table 5 presents the employment results from our sensitivity analysis. As expected, employment results are more positive under higher gas prices and lower EV costs. Net results remain positive under all sensitivities except those where EV costs are unexpectedly high and gas prices are either at or below current expectations.

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[27] According to one recent estimate, Colorado currently has about 300 employees across 20 facilities developing clean and fuel-efficient vehicle technologies. Natural Resources Defense Council and Blue-Green Alliance. 2017. *Supplying Ingenuity II: U.S. Suppliers of Key Clean, Fuel-Efficient Vehicle Technologies*. Available at https://www.nrdc.org/sites/default/files/supplying-ingenuity-clean-vehicle-technologies-report.pdf.

[28] The incremental up-front cost of new EVs and efficient ICEs is outweighed by fuel cost savings from 2030 onward, and these net savings and macroeconomic benefits only continue to increase over time. If we were to extend our study period beyond 2035, we would likely find more positive results than are presented here.

[29] U.S. Bureau of Economic Analysis. Regional Data: Gross Domestic Product By State. Available at https://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=1#reqid=70&step=10&isuri=1&7003=200&7035=-1&7004=naics&7005=-1&7006=08000&7036=-1&7001=1200&7002=1&7090=70&7007=2017&7093=levels

[30] In 2017, Colorado non-farm employment was greater than 2.6 million. U.S. Bureau of Labor Statistics. 2018. State and Area Employment: Annual Averages. Available at https://www.bls.gov/sae/eetables/sae_annavg117.pdf. Our average employment impacts of 1,724 are about 0.07 percent of this figure.

Table 5. Average Annual Employment Impacts (Job-Years), Sensitivity to EV Costs and Gas Prices

	Low Gas Price	Base Gas Price	High Gas Price
Low EV Cost	1,466	2,238	3,753
Base EV Cost	952	1,724	3,240
High EV Cost	-2,181	-1,409	106

Table 6 displays GDP results under various combinations of gas price and EV cost assumptions. Again, we find positive impacts across all sets of gas price assumptions where EV costs are at Base or Low levels. However, if EV battery costs are unexpectedly high in the future, the Clean Vehicles scenario could result in small net GDP losses.

Table 6. Average Annual GDP Impacts (2017 $Million), Sensitivity to EV Costs and Gas Prices

	Low Gas Price	Base Gas Price	High Gas Price
Low EV Cost	$81	$110	$170
Base EV Cost	$42	$72	$132
High EV Cost	-$196	-$167	-$107

4. CONCLUSION

Our analysis indicates that the combination of state clean car standards and increased EV penetration is likely to result in positive macroeconomic impacts within the state of Colorado. The magnitude of these impacts is likely to be very small in the context of the larger forces that shape the state's economy. However, over the long term these impacts are likely to grow increasingly positive and extend to nearly every facet of the Colorado economy outside of the petroleum industry and its suppliers. Importantly, our finding of positive macroeconomic impacts does not account for any of the emission reduction benefits that are typically a primary goal of fuel economy and EV policies. Our analysis therefore indicates that these environmental and health benefits can be achieved alongside employment and GDP growth in Colorado.