COLORADO
Energy Office

Colorado Light-Duty Vehicle Electrification Roadmap

100 Percent by 2050

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Authors	Jane Culkin, Dave Seamonds, Paul Moynihan
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ERM Consulting & Engineering, Inc.
One Beacon Street, 5th Floor
Boston, MA 02108

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Acronyms and Abbreviations

Name	Description
$/kW	dollar per kilowatt
$/MT	dollar per metric ton
ACC II	Advanced Clean Cars II
AEO	Annual Energy Outlook
AQCC	Air Quality Control Commission
AV	autonomous vehicle
BEV	battery-electric vehicle
CARB	California Air Resources Board
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health & Environment
CEO	Colorado Energy Office
CEVC	Colorado Electric Vehicle Coalition
CH_4	methane
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
COBRA	CO-Benefits Risk Assessments Health Impacts Screening Mapping Tool
DCFC	direct current fast charger
EDF	Environmental Defense Fund
EIA	Energy Information Administration
EV	electric vehicle
EVSE	electric vehicle supply equipment
FCEV	fuel cell electric vehicle
FHWA	Federal Highway Administration
g/gallon	grams per gallon
g/kWh	grams per kilowatt-hour
GHG	greenhouse gas
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
GVWR	gross vehicle weight rating
GWP100	global warming potential over a 100-year period
HOA	Homeowners' Association
ICCT	International Council on Clean Transportation
ICE	internal combustion engine
IECC	International Energy Conservation Code
IWG	Interagency Working Group on the Social Cost of Greenhouse Gases
kW	kilowatt
kWh	kilowatt-hour
LD	light-duty
LDV	light-duty vehicle
LEV	low-emission vehicle
LEZ	low-emission zone
MFH	multi-family housing
MJB&A	M.J. Bradley & Associates, LLC
MOU	memorandum of understanding
MOVES	Motor Vehicle Emission Simulator
mpg	miles per gallon
MT	metric ton
MW	megawatt
MWh	megawatt-hour
N_2O	nitrous oxide

NEVI	National Electric Vehicle Infrastructure Formula Program
NGCC	natural gas combined cycle
NOx	nitrogen oxides
PEV	plug-in electric vehicle
PHEV	plug-in hybrid-electric vehicle
PM	particulate matter
PUC	Public Utilities Commission
RAQC	Regional Air Quality Council
TCO	total cost of ownership
TNC	transportation network company
TZEV	transitional zero-emission vehicle
VCE	Vibrant Clean Energy, LLC
VMT	vehicle miles traveled
WTW	well-to-wheel
ZEV	zero-emission vehicle
ZEZ	zero-emission zone

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1. EXECUTIVE SUMMARY

Transportation is the largest source of greenhouse gas (GHG) emissions in Colorado, surpassing electricity generation in 2020. Transportation electrification is a critical strategy in reducing transportation-related emissions and the State of Colorado has set ambitious goals to electrify almost a million light-duty vehicles by 2030. This Roadmap identifies and analyzes policies, programs, incentives, and other actions that the State of Colorado can adopt or develop to achieve 100 percent light-duty electrification by 2050.[1] The following sections highlight the key takeaways from this analysis and outline some of the near-, medium-, and long-term actions to achieve these electrification goals.

This Roadmap is meant to guide the development of a range of high impact policies and programs to drive forward electric vehicle adoption across the state. It has three primary components: 1) a literature review and stakeholder engagement process that highlighted best practices and provided additional context into existing marker barriers; 2) a modeling exercise that explored the significant benefits to the State of adopting a set of "core policies" that set standards and provided additional supportive strategies for light-duty electrification; and 3) a detailed policy analysis that outlines key policy opportunities for the State to consider. This report contains modeling results to determine the potential costs and benefits created from the increased levels of light-duty (LD) vehicle electrification resulting from policy implementation within Colorado. A more detailed discussion of the modeling analysis is included in the following chapters and appendix of this report. The core policies described in the sections below offer a clear pathway to achieve Colorado's ambitious electric vehicle goals and light-duty GHG emission reductions all while providing significant societal benefits that will positively impact Coloradans across the state. The analysis included in this report finds that those annual benefits could reach $4.6 billion by 2050.

However, as described below, the State, like many across the country, faces many barriers to the rapid electrification envisioned by these policies. Experience has shown across the country that these core policies are most achievable, and have the lowest cost and impact on consumers, when supported by a broad range of state and local measures that proactively reduce these barriers. Therefore, this report presents a Roadmap that highlights four categories of policies that will be critical to meeting the state's goals strategically, cost effectively, and equitably. These include measures in the categories of infrastructure development, incentives, education and outreach, and State leadership opportunities.

These complementary policies and programs, when combined with the core policies modeled within this report set the state on a pathway to ensure vehicle electrification is not only supported and that the State's ambitious targets can be met but that the societal benefits of vehicle electrification can be maximized and distributed to communities across the state, including those that are disproportionately burdened by climate change and transportation pollutants. These benefits—including improved air quality, reductions in climate warming GHG emission, utility customer savings, and vehicle owner savings—will put the state on a pathway that centers climate action around environmental justice, equity, and affordability for all Coloradans. Taken together, the actions outlined within this Roadmap will help the State meet its ambitious targets and secure significant benefits.

1.1 Key Findings

Reaching Colorado's mid-term 2030 goal of 940,000 electric vehicles on the road is achievable but will require supporting and expanding upon the State's transportation electrification actions in the near-term. There are a number of actions, outlined below, that the State of Colorado can take—from

[1] Colorado Greenhouse Gas Pollution Reduction Roadmap, Colorado Energy Office, September 30, 2020: https://drive.google.com/file/d/1lok5it22y_Eh0Fjp8ioT_BbPMC7zUJpZ/view

leveraging Federal and State funding to increasing incentives and supporting infrastructure development to creating more robust stakeholder engagement and communications strategies and programs that reach out to communities across the State including those that are disproportionately burdened by poor air quality.

There are significant opportunities for the State to expand its collaboration with a wide variety of stakeholders across Colorado. The State should continue to expand engagement with a wide variety of stakeholders by focusing State communications efforts on both increasing electric vehicle awareness and adoption amongst consumers and streamlining vehicle electrification by developing a robust light-duty electric vehicle market. Increasing engagement with communities across the State in addition to key electric vehicle stakeholders (e.g., utilities, electric vehicle supply equipment (EVSE) providers, fleet operators, transportation network companies (TNCs), vehicle technicians, municipalities, gas station operators, community-based organizations, among others) will be imperative to ensuring that vehicle electrification is developed in an effective and streamlined way that is accessible to all Coloradans.

The policies modeled as part of this report could provide over $4.6 billion in annual benefits to Colorado. As part of the 100 x 50 scenario, annual benefits such as zero-emission vehicle (ZEV) owner savings of $1.7 billion, climate benefits of $1.9 billion, air quality benefits of $0.25 billion and utility customer savings of $0.75 billion combine to provide significant annual benefits to the State.

Achieving the goal of electrifying 100 percent of light-duty vehicles by 2050 will require multiple complementary strategies. While the scenario modeling results of this analysis indicate that this goal could nearly be achieved by Colorado adopting a program modeled on the proposed California Advanced Clean Cars II (ACC II) program alone, continuing and augmenting other complementary programs and infrastructure investments will likely result in a more successful and equitable transition. The 100 x 50 scenario demonstrates that it may be possible to achieve this goal without the ACC II regulatory strategy, but only with several new policies and programs, some of which would likely require orders of magnitude greater investment levels than are currently available in the State.

The following section provides a set of high level near-, medium-, and long-term actions that the State of Colorado could implement.[2] Each action is described in more detail in the following sections and chapters of this report.

[2] The Colorado Energy Office is concurrently developing an EV Equity Study that will expand upon many of the policies focused on equitable transportation electrification that are discussed within this Roadmap. Specifically, the EV Equity Study provides additional resources and an EV Equity Toolkit to support the development of policies and programs that are centered in increasing environmental justice, equity, and affordability for all Coloradans. More information is available on the Colorado Energy Office's website: https://energyoffice.colorado.gov/zero-emission-vehicles.

1.2 Near-, Medium-, and Long-Term Actions

Table 1: Near-, Medium-, and Long-Term Roadmap Recommendations

Roadmap Recommendation	Near-Term (1-3 Years)	Medium-Term (4-7 Years)	Long-Term (8+ years)
Increase Ease of Access			
Adopt electric vehicle standards and targets that establish a meaningful electric vehicle market within the State of Colorado.	Adopt a program modeled on the proposed California ACC II program.[3] Establish new State fleet procurement targets for electric vehicles that extend beyond 2025 and evaluate the potential for an electric vehicle fleet rule, codifying requirements for large light-duty fleets.		
Work directly with dealerships across the State to increase consumer electric vehicle education.	Ensure that dealerships have the training and educational tools they need to educate consumers on differing electric vehicle models. This can take the form of educational programs, technical support related to siting and installation of charging, or increasing access to various rebate and incentive programs.		
Increase engagement with municipalities and local governments that ensures educational resources are reaching residents across the State and that enables municipal fleets to electrify more rapidly.	Support municipalities and local governments that are tackling efforts to increase EVSE deployment during site development by continuing to develop tools like the Energy Code Adoption Toolkit and resources like the Code Helpline to assist municipalities in adopting updated building codes.	Set clear programmatic review cycles and metrics that evaluate programs and policies to ensure that they meet affordability and equity goals. These metrics should be evaluated and updated periodically.	
	Evaluate and implement programs that increase support for municipal fleet electrification by working with municipal governments to develop programs that will lead to more rapid fleet electrification (e.g., bulk buy electric vehicle programs, vehicle replacement programs, among others).		
	Support local government EV readiness by developing a complementary suite of resources including grant funding for development of regional EV readiness plans, charging infrastructure grant funding, and other types of support including education, outreach, and technical assistance.		

[3] The CA Advanced Clean Cars II (ACC II) rule is currently under consideration in CA and has not been finalized. Modeling a rule on the ACC II can achieve significant electrification of the light-duty fleet by 2050.

Roadmap Recommendation	Near-Term (1-3 Years)	Medium-Term (4-7 Years)	Long-Term (8+ years)
Work with utilities to leverage their unique opportunities to advance the electric vehicle market.	The State can play a meaningful role in working with utilities to make easement and capacity maps readily available to EVSE providers. The State can also work with State regulatory and oversight bodies to ensure that utilities are utilizing State and other resources effectively to deploy charging infrastructure programming.		
	Work with utilities and other stakeholders to: 1) establish long term infrastructure build-out plans, 2) pair fleet advisory services with infrastructure development.		
	Encourage and facilitate utility collaboration across the State to enable streamlined and planned infrastructure development across investor-, municipally- and cooperatively-owned utility service territories.		
	The State should also work with utilities to implement effective charging infrastructure rates that incentivize managed charging.		
Work with large fleet owners and transportation network companies (TNC) to increase new and used electric vehicle adoption.	Partner with municipalities and other large fleet owners (e.g., vehicle rental companies, vehicle leasing companies, among others) throughout the State to evaluate ways to increase the market for used electric vehicles. Increase and incentivize public and private fleet turnover to electric vehicles in the near term to increase the number of vehicles within the secondary vehicle market.	Work with TNC companies to set targets to increase the percentage of TNC mileage that is provided by EVs before 2030.	
Increase Affordability			
Continue to support and develop incentive programming.	Consider expanding action taken through HB 19-1159 to extend tax credit availability beyond 2026 through at least 2030 with consideration through 2035.		
	Expand and increase current rebate programs through 2030.		
Develop vehicle replacement programs to increase the number of electric vehicles on the road.	Implement a high-emitting vehicle replacement program designed to encourage more rapid internal combustion engine (ICE) vehicle replacement with EVs.		

<table>
<tr><th>Roadmap Recommendation</th><th>Near-Term (1-3 Years)</th><th>Medium-Term (4-7 Years)</th><th>Long-Term (8+ years)</th></tr>
<tr><td rowspan="3">Create equity-centered incentive programs that expand the used vehicle market and increase the affordability of electric vehicles.</td><td>Provide incentives for used electric vehicles to encourage vehicle procurement and to increase the cost competitiveness of electric vehicles with used ICE vehicles.</td><td colspan="2" rowspan="2">Set clear programmatic review cycles and metrics that evaluate programs and policies to ensure that they meet affordability and equity goals. These metrics should be evaluated and updated periodically.</td></tr>
<tr><td>Explore opportunities to expand access to affordable and fair financing for vehicles and infrastructure, including potential flexibility for utilities to offer financing.</td></tr>
<tr><td rowspan="2">Develop equity-centered vehicle programming that includes community-based and multi-family charging infrastructure, car share programs, and other electrified multimodal transportation options.</td><td>Continue to support the expansion of electric car shares paired with electric micromobility specifically for disproportionately impacted communities and high emission areas.</td><td></td></tr>
<tr><td>Evaluate the role of State leadership in developing tiered leasing models based on income eligibility that are within reach for low wage earners.</td><td></td></tr>
<tr><td colspan="4">Increase Awareness</td></tr>
<tr><td>Provide educational resources for companies to help them identify strategies to increase electric vehicle usage both within their own fleet and with their employees.</td><td>State entities, in partnership with other key stakeholders like utilities, should collaborate with private fleet owners to incentivize and provide technical assistance to help fleets develop and implement vehicle electrification targets.</td><td>Establish an EV infrastructure toolkit. The State should work with local governments and regional governments to develop an infrastructure toolkit to (1) identify charger options, (2) provide utility contacts for the installation of the supporting electrical equipment, (3) recommend qualified electricians, (4) identify rebates, and (5) detail local permitting requirements.</td><td></td></tr>
<tr><td>Focus educational resources and funding to equitably electrifying communities disproportionately burdened by air emissions.</td><td colspan="3">Expand existing educational and outreach programs to target low- to moderate-income and disproportionately impacted communities</td></tr>
<tr><td>Design marketing programming to combat EV adoption barriers.</td><td colspan="3">Design and implement a comprehensive and cohesive marketing program that can combat electric vehicle adoption barriers such as range anxiety by highlighting publicly accessible charging networks around the State. Develop marketing and outreach plans to communicate and support used electric vehicle purchases.</td></tr>
</table>

Roadmap Recommendation	Near-Term (1-3 Years)	Medium-Term (4-7 Years)	Long-Term (8+ years)
Enabling a Just Transition			
Support the development of a just transition to vehicle electrification across the State.	Convene stakeholders across the entire oil and gas supply chain (from oil and gas producers to convenience store owners) to evaluate and better understand the types of programs and policies that may best support their transition to a low-carbon economy (e.g., workforce training, relocation funding, etc.)	Provide funding for job training through community college vehicle electrification programs for stakeholders across the entire oil and gas supply chain.	Continue to work with and support oil and gas workers throughout the supply chain on enabling a just transition to a low carbon future.

2. BACKGROUND

Transportation is the largest source of greenhouse gas pollution in Colorado overtaking electricity generation in 2020, consistent with the trend nationwide.[i] The Climate Action Plan to Reduce Greenhouse Gas Pollution, or HB 19-1261, set science-based climate targets to reduce statewide greenhouse gas (GHG) pollution 26 percent by 2025, 50 percent by 2030, and 90 percent by 2050 from 2005 levels, was passed by the Colorado legislature in the 2019 session. To ensure that Colorado is continuing to make progress toward these goals, Governor Polis directed State agencies to develop a comprehensive GHG Roadmap that presents options for near-term actions (the next 1 to 2 years) and assesses the potential for additional policies to make progress toward the mid-term goal in 2030 and the 2050 goal. This GHG Roadmap was released in January of 2021. It addresses GHG emissions from the transportation sector and calls for transition to close to 100 percent electric cars on the road by 2050.

In addition to the GHG Roadmap, the State is taking steps to reduce the impact such as the 2020 Colorado Electric Vehicle Plan, released in April of 2020.[ii] This plan sets a vision of the large-scale transition of Colorado's transportation system to ZEVs, with a long-term goal of 100 percent of light-duty vehicles being electric. Key elements of the light-duty sector actions part of the plan are interim goals #1 and #5 which serve as guidance for developing this 100 percent light-duty EV roadmap.

- Goal #1: Increase the adoption of EVs in the light-duty sector to approximately 940,000 EVs [battery-electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV)] on the road by 2030. This will require maintaining at least a 50 percent annual growth rate. For the near term, interim targets are to increase the number of new light-duty electric vehicles sold on an annual basis to:
  - 23,500 per year by June 30, 2022
- Goal #5 - Develop a roadmap to full electrification of the light-duty vehicle (LDV) fleet
  - As part of the development of the GHG Roadmap, the State will evaluate the necessary timeline for light-duty electrification to achieve the target of 90 percent emissions reductions by 2050.
  - The State will conduct an analysis of policy, programs, and strategies to achieve this transition and will develop recommendations for administrative and legislative action.
  - The State will participate in the development of emissions and ZEV standards for model years 2026 and after to support the changes needed to achieve full electrification of light-duty vehicles.
- Light-Duty Sector Actions
  - Action 1: CEO, CDOT, CDPHE and the RAQC will develop a roadmap for a transition to 100 percent electrification of the light-duty transportation sector. The analysis shall consider short-, mid-, and long-term strategies including public investment, administrative activity, regulatory activity, and potential legislation, as well as the opportunity to inform and participate in development of future Low Emission Vehicle (LEV) standards, Zero Emission Vehicle (ZEV) standards, and light-duty vehicle GHG emission standards.

Colorado's Air Quality Control Commission (AQCC) has adopted both the Low Emission Vehicle (LEV) and Zero Emission Vehicle (ZEV) Standards. The LEV standards, adopted in November 2018, set emission requirements for new light-duty and medium-duty motor vehicles sold in Colorado beginning with the 2022 model year. Thirteen other states besides Colorado have adopted these standards under Section 177 of the Clean Air Act (42 U.S.C.§7507). In August 2019, Colorado became the tenth state in the US to adopt a ZEV standard which requires automakers to sell more than 5 percent zero emission vehicles by model year 2023 and more than 6 percent zero emission vehicles by model year 2025. Updates to both of these standards for later model vehicles by the AQCC will be impacted by regulatory considerations and actions both at the California Air Resources Board (CARB) and at the Federal level.

Recent action by the Colorado legislature and the Polis Administration resulted in the enactment of Senate Bill 21-260, and House Bill 1266, which were signed into law on June 17, and July 2, 2021, respectively. Both of these laws provide significant resources and direction towards achieving the 100 percent LD electrification goals.

Table 2: Recent Colorado Legislative Successes

Senate Bill 21-260
New Transportation Fees: Creates new fees for purchases of gasoline and diesel fuel, EV registrations, retail deliveries, passenger ride services, and short-term vehicle rentals, including:
■ Road Usage Fee: Introduces a Road Usage fee for fuel distributors that pay excise tax, paid per gallon of gasoline and diesel.
■ EV Fee: Amends the existing $50 EV annual registration fee to be adjusted for inflation annually.
■ Retail Delivery Fee: Imposes a new fee on retail deliveries, adjusted for inflation annually.
■ Passenger Ride Fee: Creates a new fee for TNCs for each ride in a carshare ride or which the driver transports the rider in a zero emissions vehicle and a higher fee for any other ride
New State Enterprises: Creates new State enterprises funded by various fees, including those described above:
■ Community Access Enterprise: To support the widespread and equitable adoption of EVs by investing in transportation infrastructure, providing grants or other financing options to fund the construction of EV charging infrastructure, and incentivizing the acquisition of EVs.
■ Clean Fleet Enterprise: To incentivize and support the use of electric and alternative fuel vehicles by business and governmental entities that own or operate motor vehicle fleets.
■ Clean Transit Enterprise: To reduce and mitigate the adverse environmental impacts and health impacts of air pollution and GHG emissions by supporting the replacement of existing gasoline and diesel transit vehicles with electric motor vehicles.
■ Nonattainment Area Air Pollution Mitigation Enterprise: To mitigate the environmental and health impacts of increased air pollution for motor vehicle emissions in nonattainment areas resulting from the growth in TNC rides and retail deliveries.
House Bill 1266
■ Environmental Justice (EJ) Ombudsperson: Creates a position that reports to the Executive Director of Colorado Department of Public Health & Environment (CDPHE) no later than February 2022. Ombudsperson should have been a resident of one or more disproportionately impacted communities or have worked to advance EJ within disproportionately impacted communities.
■ EJ Advisory Board: Creates CDPHE EJ Advisory Board with twelve members appointed by the Governor no later than November 2021.

3. LITERATURE REVIEW

A literature review was conducted to identify existing LDV electrification transition actions, goal-making documents, and roadmaps by other municipal, state, regional and international governments

3.1 Other LDV Electrification Transition Actions

The literature review yielded different approaches that can be broadly classified as (1) legislative and executive action, (2) EV roadmap development, and (3) program and policy solutions. For each, the level of impact these actions, policies, orders, or roadmaps has had to date on increasing LDV electrification were evaluated each based on the following categories:

- Relatively meaningful success to date: Projects and programs have been implemented and progress reports have been released indicating that progress has been made towards the outlined goals.
- Awaiting next steps or only presented historical data: Plan or Order has been released and initial progress reports have been filed but available data is dated making it difficult to determine current level of success.
- Information not available or not yet developed/implemented: Plan or Order has been released but no review has been conducted making it difficult to determine if the program has been successful.
- Failed or plan no longer active: Program or Order was implemented but was unsuccessful and is no longer active.

Further detailed summaries for each of the approaches are provided in Appendix A.

3.1.1 Legislative and Executive Action

A significant leader in the US has been the ZEV memorandum of understanding (MOU) that was agreed initially by seven additional jurisdictions across the U.S. to adopt the California ZEV mandate standards.[iii,iv] Since California spearheaded the MOU in 2013, additional states have adopted the California mandate via Section 177 of the Federal Clean Air Act. A key component of the ZEV mandate will be establishing credit thresholds for different vehicle types, ranging from partial to transitional to full ZEV (PZEV, TZEV, and ZEV, respectively). This lays out a consistent pathway towards achieving the ZEV transition.[4]

International governments and specific US states have made progress in establishing the pathway to electrification with varying success – a few examples are summarized below.

United Kingdom Ten-Point Plan: The Ten-Point Plan for a Green Industrial Revolution was introduced in 2020 and since then significant strides have been made with respect to transportation electrification. The primary focal point is the ban of new gasoline and diesel cars and vans as of 2030. Investments have been committed, including £500 million for automotive sector electrification and £1.3 billion for charging infrastructure (rapid charging stations on highways as well as public charging in residential areas and near workplaces).

California Executive Order N-79-20: This order calls for 100 percent of all in-state sales of new passenger cars and trucks to be ZEV by 2035. California has made strides towards implementing this order and is currently considering legislation that can serve as the foundation for these goals (i.e., Advanced Clean Cars II rule). Of note is that the Executive Order does not define what a passenger truck is; however, the

[4] PZEV can no longer earn credits, although banked credits from previous years can be used at a discount through model year 2025.

draft ACC II regulation applies to all passenger cars, light-duty trucks, and medium-duty passenger vehicles.[5]

New York State S.2758/A.4302: This legislation was signed by NY Governor Hochul in September 2021 and sets a goal that all new passenger cars and trucks sold in New York State be zero-emissions by 2035.

Washington State E2SHB 1287: The Washington State legislature passed this bill setting a goal of all new vehicle sales in Washington State be zero-emissions by 2030. This is the most aggressive timetable of those noted here; however, it was tied to development of a road usage charge or equivalent tax. Citing the time needed to design and implement a new program to establish the road usage charge, Governor Inslee partially vetoed this portion of the bill. While ambitious, the overall legislative effort is considered unsuccessful to date as it did not establish a clear pathway forward.

3.1.2 EV Roadmaps

EV roadmap strategies generally focus on two overarching needs: vehicle turnover and infrastructure deployment. Sub-categories that are considered for each include:

- ZEV integration: incentives, leading by example by converting public fleets, supporting segment-specific turnover [TNCs, taxis, multi-family housing unit (MFH) residents, rural communities], parking management, and education and outreach
- Infrastructure deployment: incentives, permitting and siting regulations, building codes, and planning analyses
- Policy solutions like low emission zones or congestion pricing that can help accelerate and incentivize vehicle turnover or use of other modes

Key findings from the existing plans review are:

- ZEV integration timelines vary in aspiration and aggression – Los Angeles, for example, updated its goal between its 2015 and 2019 plans from 25 percent of all passenger LDV on the road will be electric or ZEV by 2035 (2015 plan goal) to 80 percent by 2035 and 100 percent by 2050 (2019 plan goal); additionally, Los Angeles' 2019 plan created more detailed goals with setting specific targets for chargers and rebates as well.
- Different approaches will be necessary for different sectors – personal vehicles, taxis (launching taxi-specific incentives and charging networks), TNCs, low-income or MFH drivers (tiered incentives).
- Many focus on leading by example through transitioning city and state agency fleets first and setting near-term targets for turnover of that fleet.
- Some approaches (e.g., Hainan, China) are done in phases with different zones prioritized first.

3.1.3 Policy Solutions

Several resources were consulted to learn about individual local policies and determined that there are a number of municipalities that are taking the initiative to design and implement EV programs.

Zero Emission Zone (ZEZ): Notably in the U.S., the city of Santa Monica is establishing a zero-emission delivery zone pilot meant to act as a blueprint for cities and provide best practices. It is a voluntary program envisioned to deploy micromobility, electric delivery vehicles, EV car sharing, priority zero-emission loading zones and curb management as well as mobile charging applications for delivery. Other

[5] GVWR: passenger cars & light-duty trucks ≤ 8,500 lb; medium-duty passenger vehicles 8,501 lb ≤ GVWR ≤ 10,000 lb; medium-duty vehicles ≤14,000 lb.

cities considering ZEZ include Madrid, London, Munich, and over 250 other cities, primarily located in Europe.[v]

Congestion Surcharge: New York City, San Francisco, Los Angeles, Singapore, London, and Stockholm are high-profile cities that are working on developing or implementing congestion surcharges. The overall goal is to reduce congestion, influence driving patterns, improve air quality, and create revenue. Of those noted, the U.S. cities remain in planning/exploratory mode, while Singapore, London, and Stockholm have implemented congestion charges. Essentially, the charge is levied on drivers that drive in dense urban zones and is meant to dis-incentivize drivers. Early success in London reduced congestion by 26 percent just three years after implementation;[vi] however, the path to implementation experienced significant negative feedback during design.

Low Emission Zone (LEZ): Much of the information available on LEZ, where inner-city zones are established to improve air quality and promote pedestrian-friendly neighborhoods is centered in European initiatives such as in Madrid and Barcelona. Common limitations are allowing only BEVs, fuel cell electric vehicles (FCEVs), PHEVs, and range-extended EVs to freely access the area with restrictions on ICE vehicles. However, in Spain, Madrid's plan has been challenged and struck down by the Supreme Court, although Barcelona's plan was first introduced in 2016 with a new implementation scheduled for 2022.[vii]

4. PRIOR STUDIES

A total of eight studies conducted between 2018 and 2020 were reviewed and ranged from independent evaluations to those that supported Colorado public actions (e.g., the Colorado GHG Pollution Reduction Roadmap). Key elements of the studies and model analyses were EV penetration scenarios in the medium- and long-term, the split between BEV and PHEV over time, and electric grid composition. Many of the models assumed that LD EV projections are normalized to the Colorado EV Plan goals of 40 percent reduction in transportation emissions, 70 percent of EV sales, and achieving 940,000 LD EVs on the road, all by 2030. Other models utilized the Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2019 reference forecast as a baseline for electrification and more aggressive year-over-year sales. Figure 1 illustrates the different LD EV penetration estimates from the three studies that provided detail on population projections. Further detail regarding the studies is provided in Appendix B.

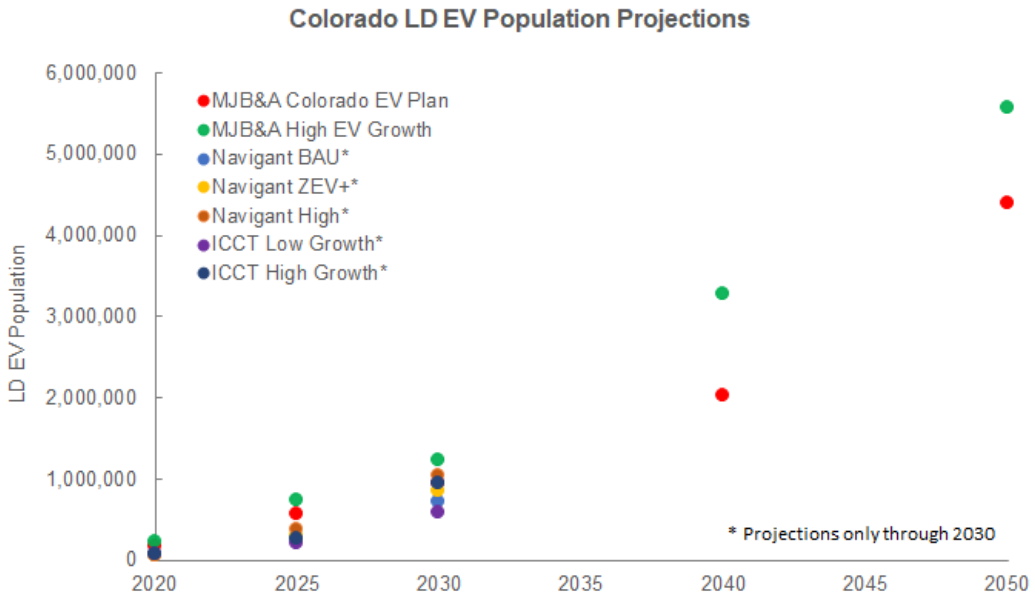


Figure 1: Colorado LD EV Population Projections

Studies reviewed are:

1. RMI Energy Policy Simulator[viii]: This report accompanies a model developed by Energy Innovation and RMI to provide 'additional analysis of policies that can drive deep emissions reductions in Colorado" [ix].
2. E3 Colorado GHG Pollution Reduction Roadmap[x]: CEO GHG roadmap presenting action-oriented and ambitious planning and strategies to reduce GHG and accomplish a clean energy transition.
3. Colorado Electric Vehicle Plan[xi] (Navigant Electric Vehicle Growth Analysis (2019)[xii]: A study developed to investigate and simulate the GHG impact of different policy options towards achieving the Colorado PEV Plan goal of 940,000 by 2030.
4. EDF Colorado ZEV Report (2019)[xiii]: An analysis to evaluate the impacts of adopting a ZEV program as a complement to the CLEAR standards.

5. Colorado Electrification & Decarbonization Study [Vibrant Clean Energy (VCE), LLC – 2019][xiv]: The basis of the study is examining changes in the electricity grid and retirement of coal – electrification of heating and transportation is a component but not the central element.
6. ICCT Colorado (2021)[xv]: An analysis to assess the home, workplace, and public charger needs across Colorado based on the statewide EV sales goal.
7. Initial Economic Impact Analysis[xvi]: This is an economic impact analysis of implementing CLEAR requirements.
8. MJB&A Electric Vehicle Cost-Benefit Analysis (2019)[xvii]: This study estimated the costs and benefits of increased PEV penetration in Colorado.

Information in Appendix B identifies targets and requirements needed in the near-, mid- and long-term to achieve Colorado's EV goals from the different studies/reports listed above. One important consideration is that the studies represent data and conclusions based on a snapshot in time. For example, the CO Electric Vehicle Plan 2020 posits that between 2021 and 2030 Colorado will have to experience more than a 50 percent growth in EV sales year-over-year to meet the 940,000 by 2030 target, with estimated target LD EV registrations of 23,500 by June 30, 2021. However, consumers have helped Colorado make better-than-planned progress in the initial years and considering just BEVs (current population of 47,006)[xviii], it may be possible for Colorado to exceed the 2030 target with a growth rate of slightly <40 percent per year.

Collectively, the studies did inform other portions of this roadmap study by providing insight into key policies, programs, and/or assumptions that were then incorporated. Key elements are:

- Prioritization of LDV electrification by State agencies
- A call for legislative action[6]
- VMT reductions
- Incentives
- Programs are needed to affect significant growth in the number of public and home chargers
- Develop time-of-use charging rates

[6] Since several of these studies were released, Colorado has taken significant legislative action (e.g., SB 21-260).

5. STAKEHOLDER ENGAGEMENT

Involving stakeholders and soliciting feedback throughout development of the roadmap was crucial to obtain a wide range of opinions and advice regarding overall direction of the roadmap and specific suggestions. Five separate stakeholder outreach meetings were held during Summer and Fall of 2021; because of the limitations of COVID-19, all stakeholder meetings were held virtually. Outreach was coordinated by CEO and for each meeting a presentation was given followed by open discussion.

Stakeholder Groups Invited

- Associations and coalitions focused on vehicle electrification, transportation, clean air
- State, city, and county governments
- Community coalitions
- Agriculture coalitions
- Community colleges
- Dealerships and dealership associations
- Original equipment manufacturers
- EVSE providers
- Fuel providers
- Non-governmental organizations focused on environmental justice, energy, environment, health, and housing
- Transportation network providers
- Electric utilities
- Distributed generation providers

Table 3: EV Roadmap Stakeholder Engagement

Meeting (#)	Objective
Kick-Off and Ensuring Equitable Engagement (1)	Kick-off stakeholder engagement discussions; level setting stakeholders on LD electrification roadmap; center the stakeholder engagement process to evaluate LD electrification through an equity lens
Public Webinar (2)	Level setting webinar on LD electrification roadmap developed for a less technical public audience.
Detailed Discussions on Infrastructure and Market Development (3 & 4)	Strategies, measures and state and local policies that should be considered within the roadmap to scale light-duty electric vehicle market and infrastructure development
Wrap-Up and Draft Roadmap Review (5)	Presentation of feedback received throughout the stakeholder engagement process allowing an opportunity for all interested stakeholders to provide additional feedback.

Throughout each of the stakeholder meetings several topics were repeatedly raised along with other targeted suggestions. Equitable implementation and a just transition were overarching themes. The following high-level topics areas were included within the discussion. The key takeaways from this stakeholder engagement process that informed the development of this Roadmap are highlighted within the Roadmap section of this report.

- Addressing Costs
- Addressing Equity and a Just Transition
- Sector Specific Engagement
- Program/Policy Development
- Education and Communication
- Infrastructure Development

6. POLICIES, FACTORS, STRATEGIES, ACTIONS

6.1 Market Barriers and Existing Gaps to Transportation Electrification

The following sections of this report highlight the barriers and opportunities to achieving full light-duty electrification in Colorado including those related to policy, administrative strategy, and marketplace development.[7] The barriers and opportunities have been informed by conversations with stakeholders and research into other EV transition plans, both within the US and internationally. While the electric vehicle market has grown significantly within the last several years, it still faces barriers that inhibit future growth including electric vehicle ease of adoption, affordability, awareness, and enabling a just transition.[xix],[8]

Ease of Adoption: Access to electric vehicles and other forms of electrified mobility remain a significant barrier to reducing transportation emissions. While this report focuses on light-duty electrification, ride sharing and ride hailing services – as well as taxis, e-bikes, and e-scooters – will also be part of transportation decarbonization. These services must be planned for to ensure that vehicle electrification is paired with reductions in vehicle miles traveled (VMT).[9] As the market develops, accessibility needs are likely to change. For example, when electric vehicle adoption is low, the priority for increasing market accessibility is targeted at first movers in the space (e.g., higher-income consumers looking to purchase a new vehicle, who are knowledgeable about State tax incentives and rebates, and who own their own home or have access to reliable charging locations). As electric vehicle adoption grows, accessibility must expand beyond these consumers to include used car buyers, consumers who live in rental properties or multi-family housing units (MFU), customers who may be experiencing an electric vehicle for the first time, and other market segments. Reaching 100 percent light-duty electrification will require finding solutions that increase accessibility for each type of these consumers.

Affordability: The up-front costs are still higher for most models of electric cars and light-duty trucks when compared to their gasoline-powered equivalents. While total cost of ownership is lower than gasoline vehicles and the price of electric light-duty vehicles has decreased, for most vehicle owners, the upfront cost is still high especially for consumers who primarily purchase used vehicles (approximately 70 percent of vehicle consumers within the United States).[xx] The cost of charging infrastructure can also present a barrier for some customers. While both issues are alleviated in part by rebates, tax credits and grant programs, awareness of those opportunities needs to be more widespread, and efforts must be taken to help spur adoption in communities where a high up-front cost is a key limiting factor and will continue to be a barrier even with the incentives and programs outlined above. It is estimated that by the end of this decade, the price of most models of light-duty electric vehicles will be cost competitive.[xxi] In the meantime, however, to reach vehicle sales targets, a combination of education and outreach, incentives, and programs that evolve overtime as the market continues to mature will be needed.

[7] The Colorado Energy Office is concurrently developing an EV Equity Study that will expand upon many of the policies focused on equitable transportation electrification that are discussed within this Roadmap. Specifically, the EV Equity Study provides additional resources and an EV Equity Toolkit to support the development of policies and programs that are centered in increasing environmental justice, equity, and affordability for all Coloradans. More information is available on the Colorado Energy Office's website: https://energyoffice.colorado.gov/zero-emission-vehicles.

[8] Communities and customer segments across the state each experience many of the barriers described below but will not necessarily respond to the same set of policy interventions. While many of the policy approaches described throughout this report impact a number of these segments, some market segments — because of differences in socio-economic characteristics, vehicle usage patterns, turnover rates, and vehicle availability — may require unique strategies.

[9] While the specific goal of this report is to develop a roadmap for light-duty vehicle electrification within the State of Colorado, multiple stakeholders who were part of the development of this report highlighted the need for this roadmap to be integrated into other multimodal State initiatives to decrease VMT and increase the use of other forms of transportation.

Awareness: Individuals and fleet owners alike must become increasingly aware of the basics of electric vehicle ownership including information about the availability and advantages of electric vehicles, the high quality of vehicle performance, the availability of models, and the ease and options for vehicle charging to feel comfortable in transitioning their company and personal vehicles to electric options. The State of Colorado can play an important role in providing educational resources and convening key stakeholders to ensure that these messages reach Coloradans across the state and continuing efforts developed as part of the Electric Vehicle Education and Awareness Roadmap.[xxii]

Just Transition: As the State transitions to a zero-carbon transportation future it must ensure that no community is left behind in the transition including both disproportionately impacted communities and those with a high percentage of oil and gas workers. There are several actions that the State can take to support the growing electric vehicle supply chain and to enable the transition of workers from the ICE vehicle supply chain.

Table 4 highlights the key market players and impacted entities evaluated within this section.[10]

Table 4: Market Players and Impacted Entities

Light-Duty Market Segments	Customer Segments and Communities	Additional Market Players
State and Municipal Fleets	Low- to moderate-Income (LMI) and Disproportionately Impacted Communities	Electric Vehicle Supply Chain (e.g., OEMs, Dealerships, Charging Providers)
Private Fleets		
Used Vehicles	Rural Communities	Electric Utilities
General Public	Urban and Suburban Communities	Oil and Gas Supply Chain (e.g., gas suppliers, convenience store and gas station owners and operators)
TNC and Shared Vehicles		

Tables 5 and 6 briefly highlight the primary barriers to implementation for each of the entities identified above. Each of these barriers are discussed in more detail in the following sections.

[10] The barriers and opportunities highlighted within this section were developed utilizing both previous research and analysis conducted on behalf of the State, information gathered through a stakeholder engagement process conducted as part of this Roadmap development, and research conducted by ERM and its predecessor organization M.J. Bradley & Associates, LLC.

Table 5: Primary Implementation Barriers

Market Players and Impacted Entities		Procurement Cycles	EV Awareness	Performance Concerns	EVSE	Model Availability *	High Upfront Cost	Used EVs
Light-Duty Market Segments	State & Municipal Fleets	X	X	X	X	X	X	
	Private Fleets	X	X	X	X	X	X	X
	Ridesharing / TNC		X	X	X	X	X	X
	General Public		X	X	X	X	X	X
		Lower Household Income	EV Awareness	Limited New Vehicle Ownership	Limited EVSE Investment	Lack of Available EVSE	Limited Home Ownership	Limited Parking
Customer Segments and Communities	Low- to Moderate Income and Disproportionately Impacted Communities	X	X	X	X	X	X	X
	Rural Communities	X	X	X	X		X	
	Urban and Suburban Communities				X	X		

* Lack of Availability from Original Equipment Manufacturers (OEMs).

Table 6: Barriers for Additional Market Players

Additional Market Players	Primary Barriers
Electric Vehicle Supply Chain	Dealerships: Lack of dealership offerings and educational resources; potential for business model changes due to lower maintenance revenue Charging Providers: lack of a sustainable business model without government and utility subsidies. Workforce Development: Lack of EV workforce training and retraining for repair and automotive supply industry
Existing Oil and Gas Workforce	Workforce Development and Just Transition: Concerns surrounding lack of workforce retraining programs across entire supply chain (gasoline suppliers to convenience store and gas station operators)
Electric Utilities	Lack of clear fleet planning projections from consumers in their territory Lack of flexibility in utility planning processes Concerns surrounding future load characteristics and buildout of grid infrastructure to meet new load

6.2 Light-Duty Market Segments

The light-duty market makes up 90 percent of registered vehicles within the State of Colorado. These vehicles span publicly and privately owned fleets, ride-hailing vehicles, and personal passenger vehicles. While each of these market segments experience some of the same barriers to electrification (e.g., high upfront costs, lack of model availability from OEMs, among others) there are unique characteristics within each of these customer segments that may require different policy and programmatic interventions. The following sections highlight some of these barriers and opportunities.

6.2.1 State and Municipal Fleets

The State of Colorado can increase light-duty vehicle electrification by leading by example within its own vehicle fleet and by encouraging municipalities throughout the state to take a leadership role in vehicle electrification. This represents a significant opportunity not only because state and municipal governments own a sizable number of vehicles (almost 17,000 light-duty vehicles as of February 2021) but also because state and municipal governments control the procurement cycles of these vehicles and can prioritize or require that new purchased vehicles are electric, thereby increasing the rate of vehicle electrification.[xxiii] Government owned vehicles also often have usage patterns that make them well suited for electrification.

Recognizing these benefits, Governor Polis issued executive order (EO) 2018 026 Concerning the Greening of the State Government that sets GHG emission reduction goals for State fleet vehicles, specifically setting a State fleet reduction goal of at least 15 percent by the end of fiscal year (FY) 2022-2023 compared to a FY 2014-2015 baseline.[xxiv] Under this Executive Order, State agencies and departments are directed to prioritize the purchase of electric vehicles used for light-duty applications including plug-in hybrid electric vehicles (PHEVs) or battery electric vehicles (BEVs).[xxv]

The State has already made significant progress in electrifying its fleet by increasing the number of electric vehicles in the fleet from 64 in FY 2019 to 239 in FY 2021. With more

Primary Barriers – Public Fleets

Procurement cycles: Public fleets (like other fleets) tend to be on regimented procurement cycles based on available funding. This can lead to a delay in vehicle electrification if the rate of ICE vehicle retirement and electric vehicle procurement is not increased. Setting clear targets that require both faster fleet turn-over and retirement of ICE vehicles and a more rapid procurement of electric vehicles could lead to a more rapid development of both light-duty electric vehicles with State and municipal fleets but also across the State as the electric fleet turns over and more public fleet electric vehicles enter the secondary vehicle market.

Perceived Performance Concerns: Certain public fleet vehicles have use cases that require consistency and reliability for emergency preparedness (e.g., police vehicles). For these vehicle types, having a coordinated charging plan and education campaign will be important to both ensuring reliability and instilling confidence in electrified vehicles.

Infrastructure: Lack of infrastructure development for all electric vehicles remains a consistent barrier to increasing the rate of transportation electrification. Like other fleets, State and municipal fleets need consistent and reliable charging that is available when needed and allows for overnight charging. This often requires the use of depot charging rather than public charging infrastructure, though these items do not necessarily have to be mutually exclusive. State and municipal governments can not only develop charging infrastructure that meets their fleet requirements but also could be used for public charging in public facilities throughout the State.

Lack of available models: Certain vehicles within public fleets (like other light-duty market segments) may not have electrified models that are readily available for procurement (e.g., electrified SUVs and pick-up trucks. While more models are being announced every day, public fleets should also evaluate if currently available electrified vehicles could also be utilized under certain circumstances (e.g., replacing an SUV for an electrified sedan).

than 150 EVs on order in the most recent cycle, the State is approaching the Governor's goal of 375 ZEVs within the State fleet by January 2022.[xxvi]

Similar to state fleets, municipal fleets are also often considered "low-hanging fruit" for vehicle electrification because they are owned and operated by government entities and are used in ways that are conducive to electrification. Municipalities also have the benefit of, in many cases, having smaller geographies which can allow their fleet to be able to charge overnight without needing additional daytime charging locations thereby easing charging constraints. While both of these considerations make municipal fleets easier to electrify, smaller municipalities can be fiscally constrained and, because of their size, can be outcompeted by larger municipalities for federal funding needed to reach electrification goals.

Several municipalities throughout the State have made vehicle electrification a priority. In 2018, the GoEV City Program was launched to help cities and municipalities set bold targets for electric vehicle adoption. Current program participants include Avon, Boulder, Denver, Fort Collins, Golden, Boulder County, and Summit County.[xxvii],[xxviii]

GoEV City Program

Cities and counties within the GoEV City Program have pledged to develop a transportation and electrification plan with strategies required to meet set goals. Some of the goals include:

- 100 percent of new light duty vehicles purchased by the county will be electric when the technology accommodates. All new sedans will be electric starting in 2020; all new SUVs will be electric by 2025; and all new pickup trucks will be electric by 2030.
- Support the electric vehicle charging station infrastructure needed to accommodate the transition to electric fleet vehicles.
- Work with municipal partners and shared fleets such as taxis, Uber, Lyft, and carshare companies to transition these shared fleet vehicles to a full electric fleet by 2030.
- Work with the community on programs, policies, incentives, and regulatory approaches to transition 30 percent of all vehicles within the county to zero emissions by 2030, and 100 percent of all vehicles by 2050.

The GoEV City program allows local governments to lead by example and promote EV readiness throughout the community.

6.2.1.1 Recommendations

Both State and municipal fleets should build upon existing policies and programs by taking the following actions.

- Establish new public fleet procurement targets for electric vehicles that extend beyond 2030.
- Evaluate current charging infrastructure needs and invest in infrastructure that is dedicated, reliable and allows for consistent overnight charging.
- Evaluate ways to increase support for local fleet electrification by convening local and municipal governments to evaluate programs that will lead to more rapid fleet electrification (e.g., bulk buy electric vehicle programs, vehicle replacement programs, among others).

- Partner with municipalities and other large fleet owners (e.g., vehicle rental companies, vehicle leasing companies, among others) throughout the State to evaluate ways to increase the market for used electric vehicles. These discussions should evaluate the role that public and private fleet owners can have in creating a used electric vehicle marketplace where consumers can compare and learn more about electric vehicles.

Primary Barriers – Private Fleets

Procurement cycles: Private fleets (like other fleets) tend to be on regimented procurement cycles based on available funding. This can lead to a delay in vehicle electrification if the rate of ICE vehicle retirement and electric vehicle procurement is not increased. Setting clear targets that require both faster fleet turn-over and retirement of ICE vehicles and a more rapid procurement of electric vehicles could lead to a more rapid development of both light-duty electric vehicles across the state as the electric fleet turns over and more public fleet electric vehicles enter the secondary vehicle market.

Lack of EV awareness and understanding of existing offerings: For many private fleet operators, the task of evaluating vehicle electrification opportunities and concerns that electrification will impact operations can limit their willingness to be first movers in transitioning their fleets. Providing increased outreach and education about the benefits of fleet electrification, coordinating with key stakeholders, like utilities, to develop fleet advisory services, and providing additional incentives for fleet electrification can play a large role in encouraging fleet electrification.

Infrastructure: Lack of infrastructure development for all electric vehicles remains a consistent barrier to increasing the rate of transportation electrification. While some fleets will require a combination of public and private charging, many more will require almost exclusively depot charging. Developing incentives and providing educational services that target private fleet electrification will enable fleet operators to have a better understanding of the amount of charging infrastructure needed to effectively charge their light-duty fleets. Fleet operators should be encouraged to develop infrastructure that meets the needs of not only their light-duty vehicles but also, where applicable, their medium- and heavy-duty vehicles.

Lack of available models: Like public fleets, private fleets also suffer from a lack of model availability. While not applicable to all private fleet use cases—for example, certain tasks may require a truck bed for storing or transporting materials which will necessitate a larger light-duty vehicle—private fleets should evaluate their current fleet vehicles and determine if certain vehicles that have available electrified models could replace other vehicles.

6.2.2 Private Fleets

Private fleets also represent a significant opportunity for light-duty electrification. Like public fleets, private fleets tend to have shorter vehicle replacement cycles when compared to privately owned vehicles. These shorter turnover rates can lead to increased deployment of not only new electric vehicles but, over time, could help develop the used electric vehicle market within the state. A recent analysis by the Climate Group shows that if fleet electrification is accelerated, the size of the used electric vehicle market could be approximately 40 percent larger by 2030 and 70 percent larger in 2040.[xxix] This significant increase in used EVs would improve availability and affordability for individuals and organizations and could increase the residual value of EVs.

6.2.2.1 Recommendations

The State should work with private fleets to encourage light-duty vehicle electrification by taking the following actions.

- State entities, in partnership with other key stakeholders like utilities, should collaborate with private fleet owners to incentivize and provide technical assistance to help fleets develop and implement vehicle electrification targets and educate fleets on incentives available for fleet electrification.
- Work with large private fleet operators to set clear light-duty electrification targets that require increased electric vehicle purchases and a more significant retirement of ICE vehicles.

6.2.3 Ridesharing and Transportation Network Providers

Transportation network companies (TNCs)[11] have unique vehicle constraints that create specific barriers to vehicle electrification. The vast majority of TNC vehicles are privately owned and have higher daily trip miles than the average non-fleet vehicle. While electrification can lead to increased vehicle savings for a high VMT vehicle (e.g., reductions in maintenance costs overtime) it can also lead to constraints that limit electric vehicle adoption (e.g., lack of charging infrastructure, vehicle charging time limiting number of customer trips). While barriers exist, the opportunities for electrification are significant. A study conducted by UC Davis found that the emissions benefits of electrifying a TNC vehicle are three times greater than electrifying a gas-powered personal vehicle due to the vehicle's high daily miles traveled.[xxx]

Several initiatives have been developed within the State to support electrified solutions for ridesharing vehicles. The State of Colorado modified its electric vehicle tax credit to allow TNC companies (e.g., Lyft, Uber) to take a larger tax credit for leased electrified vehicles.[xxxii] The State also passed legislation to exempt car sharing vehicles from a daily car rental fee.[xxxiii] These changes enabled TNC companies to lease electric vehicles, which are typically eligible for a smaller tax credit, to their drivers on a weekly basis. After this change was made, in 2019, Lyft created the Denver Express Drive program which helped lease 200 long-range electric vehicles to TNC drivers.[xxxiv] Drivers who participated in the Denver Express Drive program have saved approximately $70 - $100 per week on fuel costs alone.[xxxv]

Primary Barriers – Ridesharing

High upfront costs: A key barrier to vehicle electrification for TNC drivers is the high upfront cost of an electric vehicle. The average TNC driver makes around $34,000 per year. The average new EV costs $52,000, more than $11,000 higher than a full-size ICE vehicle and more than $30,000 than the average compact car.[xxxi] This disparity in earnings and upfront vehicle cost is prohibitive for many TNC drivers. Like the majority of drivers across the US, TNC drivers also do not tend to buy new vehicles and instead purchase their vehicles in the used market. Addressing these high upfront costs by increasing the accessibility of used electric vehicles could significantly increase electric vehicle adoption amongst TNC drivers.

Lack of EV awareness and understanding of existing offerings: As with other vehicle owners, evaluating vehicle electrification opportunities and concerns that electrification will impact their vehicle usage can limit TNC driver's willingness to be first movers in transitioning their vehicles.

Infrastructure and charging access: Lack of infrastructure development for all electric vehicles remains a consistent barrier to increasing the rate of transportation electrification. TNC vehicles are usually personally owned vehicles that must be charged at least a portion of the time at the driver's residence. This can create issues if the driver lives in multi-family housing that does not currently have access to charging. TNC drivers are further limited if they do not have readily accessible public fast charging. A study by the American Council for an Energy Efficiency Economy found that not enabling a system by which TNC drivers have easily accessible public and residential charging can lead to lost wages for drivers if they spend a disproportionate amount of time looking for stations to charge their vehicles.

6.2.3.1 Recommendations

The State should continue to work with TNCs and TNC drivers to encourage light-duty vehicle electrification by taking the following actions.

[11] Transportation network companies (TNCs), also known as ride-hailing companies, provide on-demand transportation services for passengers.

- Continue to support and provide incentives to EV leasing programs for TNC drivers.
- Work with TNC companies to educate drivers on the EV offerings provided by the State.
- Subsidize electric car sharing services for TNC drivers paired with electric micromobility specifically for disproportionately impacted communities and high emission areas.

6.2.4 Used Vehicle Market

Developing a used electric vehicle market will be critical to achieving 100 percent light-duty transportation electrification. While 70 percent of car sales in the United States are for used cars, most electric vehicles are newer models. This creates a disconnect between the supply and demand of electric vehicles that meet both consumer preferences and budgets. The State of Colorado will need to not only encourage the purchase of new electric vehicles but must also increase the turnover rate for both used ICE vehicles and new electric vehicles to reduce the amount of ICE vehicles on the road and increase the number of available used electric vehicles.

While the State has not developed a used electric vehicle program, other states have begun to explore opportunities to grow the market for used electric vehicles. For example, California's Clean Cars 4 All program helps bring clean transportation technology to lower-income consumers by allowing participants to replace an older vehicle with a new or used electric vehicle or an alternative mobility option like public transit passes or electric bikes. Eligible participants can receive up to $9,500 to purchase a new or used PHEV, BEV, or FCEV or receive up to $7,500 for public or private shared mobility options. Utilities have also deployed programs that encourage the purchase of used electric vehicles. For example, Xcel Energy offers a $3,000 rebate for a used vehicle for income-qualified customers.[xxxvi]

6.2.4.1 Recommendations

Developing a used market for electric vehicles has the potential to dramatically reduce the upfront cost of the vehicle thereby making electrification a more reasonable option for Coloradans across the state including lower income residents who may otherwise be unable to afford the sticker price of a new vehicle. The State could assist in developing a market for used electric vehicles by implementing the following.

- Provide incentives for used electric vehicles statewide to encourage growth and to make used electric vehicles more cost competitive with used ICE vehicles. (e.g., California Clean Vehicle Assistance Program).[xxxvii]
- Identify and engage with used vehicle dealerships and online marketplaces to better understand the market differences between new and used vehicles and potential challenges to educating used vehicle buyers on the benefits of electric vehicle ownership.
- Increase and incentivize public and private fleet turnover to electric vehicles in the near term to increase the number of vehicles within the secondary vehicle market in the future.
- Develop marketing and outreach plans to communicate and support used electric vehicle purchases.

6.2.5 Leveraging State and Federal Funding to Drive Electrification

Financing light-duty transportation electrification will require the collective resources of federal, State, utility, and local entities in addition to private sector funding. Several critical pieces of legislation have passed at both the State and federal levels of government that will have a meaningful impact on the State's ability to meet its targets if utilized efficiently.

Through the passage of SB21-260 in June 2021, Colorado established three new enterprises (Community Access, Clean Fleet, Clean Transit) that collectively are projected to provide over $730 million in funding to incentivize ZEV infrastructure and vehicle deployments over the next 10 years. The new State enterprises will enable a sustainable transportation system by helping to modernize the infrastructure needed to support the widespread adoption of electric vehicles and mitigate adverse environmental and health impacts of transportation system use. While the revenues for the enterprises will begin being collected in July of 2022, the State will still have to leverage additional federal grant and incentive funding pools while internally developing Colorado-centric policies and funding streams to address the cost differentials between now and 2030, after which ICE cost-parity is predicted for a portion of the light-duty vehicle market.

In November 2021, Congress passed the Infrastructure Investment and Jobs Act (IIJA), more commonly referred to as the Bipartisan Infrastructure Law, which authorized $1.2 trillion in total federal spending that includes funding for a wide variety of projects and programs ranging from funding new roads and bridges to building out electric vehicle charging infrastructure.[xxxviii] While an important funding stream, many of the new grants supported by the IIJA will require additional state level matching – up to 20 percent in many cases. Key transportation electrification funding streams that are relevant to Colorado's light-duty electrification roadmap are included in Appendix C.

6.2.5.1 Recommendations

While each of the above funding streams will likely be important to the development of many of the policies and programs described within this roadmap, it is important that Colorado think critically about how and where these investments should be deployed to achieve the greatest impact. This will mean not only stacking policies and programs in a manner

Understanding Differing Customers and Communities

The existing make-up and preferences of drivers within communities across the state create differing barriers to transportation electrification. Some of these differences stem from the existing community demographics and community characteristics (e.g., building stock and density, types of roadways and accessibility to commercial districts). For example, most rural homes are single family whereas urban areas tend to have more multi-family housing. This increase in single family homes can make residential charging easier in rural communities and more difficult in urban areas where access to overnight charging might be more difficult. Conversely, urban drivers tend to drive less and therefore are likely to manage their daily commutes on one charge which can be beneficial if they have access to home or work charging. Rural drivers on the other hand are likely to travel further for typical tasks which may require more public chargers.

Another noticeable difference between rural and urban populations is that rural populations tend to be older. Elderly populations may be less inclined to invest in new technologies which could lead to a lag in private investment in electric vehicle supply equipment (EVSE) infrastructure in rural areas where the utilization of the charger might be low initially.

Importantly, there are some noticeable similarities between rural communities and low-to moderate- income (LMI) communities and disadvantaged communities within urban areas that should be considered when programs and policies are developed. Like rural communities, disadvantaged communities also suffer from low utilization of chargers initially due to lower rates of vehicle ownership and increased used vehicle ownership leading to slower charger utilization rates. This lack of investment can lead private infrastructure developers to leave these communities behind and only invest in the areas where they believe the market is mature enough to invest (typically wealthier suburban and urban communities).

Within many communities, at least in the near term, there is likely a role for public investment and utility support in these spaces to ensure that no communities are left out of this transition.

that will create a sustainable market for electric vehicles but will also mean developing policies that may address specific market barriers that vary based upon differing customer segments and communities across the state.

6.3 Infrastructure Development

Developing residential, commercial, and fast charging networks that span the entire state, are reliable, and service multiple electric vehicle types will be important. State leadership can play a key role in convening stakeholders to identify what infrastructure will be required to reach 100 percent light-duty electrification. While there are commonalities across states and regions, when actual infrastructure is beginning to be installed and as vehicle deployments scale, State leaders will need detailed and forward-looking electrification planning processes that consider the rollout of various vehicle types and where they are likely to charge or be refueled.

Without clear plans and policies that require the installment of charging infrastructure across the state, customer concerns (e.g., range anxiety, infrastructure expense, and consistency in “fuel” prices across service territories and regions), may limit vehicle owners' desire to procure a ZEV. By supporting a long-term planning process that includes insights from key stakeholders (e.g., OEMs, fleet operators, TNCs, utilities, private infrastructure providers, government agencies, and community members and advocates) State leadership can begin to develop an electrification pathway that includes the differing needs of multiple stakeholders.

Since the development of Colorado’s 2020 Electric Vehicle Plan, the State hired the International Council on Clean Transportation (ICCT) to conduct an electric vehicle infrastructure gap analysis. The report included a number of important key findings related to the current infrastructure needs within the state to reach 2030 electric vehicle targets. Importantly, the report found the following charging infrastructure would be needed if the State were to achieve a high growth scenario which assumes 80 percent of the 2030 electric vehicle stock will be BEVs and 20 percent will be PHEVs.[xxxix]

- Public charging infrastructure needs: Public chargers must grow from about 2,100 in 2020 to about 24,000 in 2030 (80 percent will be Level 2 (L2) and 20 percent will be DC fast chargers (DCFC)).
- At home charging infrastructure needs: To meet the 940,000 EVs by 2030 goal, 437,000 at home or multi-family housing chargers will be needed by 2030.

The report also found that, over time, the State will need to develop increased charging capacity in addition to expanding electric vehicle charger coverage. For example, the report found that more densely populated counties within the state will require more L2 and DCFC chargers than more rural locations (See Table 7) and found that about two to three DCFC per mile of highway are needed along charging corridors that have been identified as having the most daily VMT, such as Interstate 25, Interstate 70, Interstate 76, and the Denver-Aurora-Lakewood and Boulder metropolitan areas.[xl] For the rest of the state, charging corridors would need about one DCFC per 10 miles of highway.[xli] The study found that the total cost for the additional infrastructure would reach about $860 million from 2021 to 2030, with total DCFC costs at 39 percent followed by home charging at 33 percent, workplace charging at 18 percent, and 10 percent for public L2 chargers.[xlii] While it is likely that the required funding will come from a number of sources (e.g., Federal and State grants and programs, public and private investment and utility investment, among others), it will be important for the State to begin evaluating these funding streams to ensure timely infrastructure investment.

Table 7: Region-Specific Charging Infrastructure Needs[xliii]

Region	Infrastructure Needs
Highly trafficked charging corridors: Interstate 25, Interstate 70, Interstate 76, and the Denver-Aurora-Lakewood and Boulder metropolitan areas	About 2 to 3 DCFC per mile
Charging corridors for the rest of the state	About one DCFC per 10 miles of highway
Adams, Arapahoe, Boulder, Denver, Douglas, El Paso, Jefferson, and Larimer counties	1,400 to 3,400 Level 2 chargers and 300 to 850 DCFC by 2030
Broomfield, Eagle, Elbert, Garfield, La Plata, Mesa, Pueblo, and Weld counties	100 to 800 Level 2 chargers and 25 to 185 DCFC

The report found that targeted investment should go towards building out DCFC and home charging, as those two types of charging represent about 70 percent of the charging infrastructure costs from 2021 to 2030.

To achieve these infrastructure targets, Colorado will need to leverage sustainable funding sources such as those from the previously mentioned SB 21-260 electrification enterprises.

Colorado has already increased charging infrastructure within the state by providing a variety of funding opportunities, outlined below:

- In November 2018, CEO awarded $10.3 million in grant funding to ChargePoint for DCFCs in 34 locations along six charging corridors including interstates, state, and federal highways.[xliv] Since then, CEO in partnership with ChargePoint and site hosts (like governments, utilities, or private companies) has built high-speed charging stations in 19 locations with the remaining locations to be completed by the end of summer 2022.[xlv]
- Beginning in 2020, CEO made grant funding available to install DCFC plazas in high-density areas and near transit hubs like the Denver International Airport. CEO just closed its third period for this program on October 30, 2021.[xlvi]
- Charge Ahead Colorado also provides grant funding for EV charging infrastructure. These grants fund up to 80 percent of L2 and DCFC chargers, with particular interest in community-based charging stations such as workplaces, tourist destinations, and multi-family housing.[xlvii] Since the establishment of the Charge Ahead Colorado Program in 2013, CEO and RAQC have funded over 1,500 charging stations.[xlviii]
- There has also been additional investment led by utilities (see The Role of Utilities in Light-Duty Electrification section below).

6.3.1 Recommendations

In addition to the infrastructure opportunities highlighted above, the State should also consider implementing the following infrastructure policy elements.

- Tier residential charger rebates based on income eligibility: The State should provide charger and vehicle incentives that prioritize low-income communities to help community members in both rural and urban populations, living in single-family and multi-family units, better access electric vehicles.[xlix]
- Partner with utilities: Local utilities can offer technical expertise on charging infrastructure upgrades, support charging stations and can provide, pending regulatory approval in the case of investor-owned utilities, a number of different types of programs designed to incentivize the deployment of chargers within both public and private spaces (see The Role of Utilities in Light-Duty Electrification section below).
- Work with EVSE Providers and site hosts to ensure a reliable and consistent charging experience: Not only do electric vehicle drivers need charging infrastructure to be installed but chargers also need to be maintained to ensure consumer confidence and limit range anxiety.
- Ensure an equitable distribution of charging infrastructure: The State should continue to provide no-cost training and technical assistance to encourage local governments across the state to adopt electric vehicle ready requirements in building codes for new residential buildings and incentivize the installation of electric vehicle charging stations in leased multi-unit dwellings.[l,12]

Developing a Community Based Infrastructure Plan - Summit County's Electric Vehicle Readiness Plan

While most electric vehicles have a battery range that far exceeds the average miles a typical driver travels in a day, range anxiety remains a key barrier for many drivers considering an electric vehicle purchase. To address these concerns, Summit County's Electric Vehicle Readiness Plan uses a ratio of one charger to every 25 electric vehicles. The county has developed a charging goal that supports their electric vehicle target of 10,440 electric vehicles on the road by 2030. To achieve this infrastructure goal, the plan identified three incentive programs to facilitate electric vehicle charging infrastructure in addition to evaluating infrastructure gaps. Key elements of the infrastructure plan are outlined below.

Incentive program for electric vehicle charging infrastructure. Local municipalities will need to provide rebates for residents who install home charging ports and provide tax credits for new EV purchases to reduce upfront costs of installing charging infrastructure.

Electric Vehicle Homeowners' Association Working Group. The working group aims to encourage homeowners' associations (HOAs) to install charging infrastructure for residents and visitors including residents who live in multi-family housing and would rely on communal charging.

Continued Coordination with Utilities. Summit County will continue to coordinate with Xcel Energy to identify any charging gaps that may arise in the future. The County and Xcel will provide resources and assistance to all businesses, property managers, and HOAs that are interested in installing charging stations. This constant contact will help identify ideal locations for additional charging locations.

[12] The ICCT study found that about 85% of the chargers needed to meet the State's electrification goals are for detached homes, 10 percent are for attached homes, and 6 percent are for multifamily housing. Workplace chargers and public chargers represent about 9 percent and 6 percent of the total chargers, respectively.

6.4 The Role of Utilities in Light-Duty Electrification

Transportation electrification will require significant planning, logistics, and infrastructure development. The State funded ICCT electric vehicle infrastructure gap analysis report found that 9.9 GWh of electricity is needed daily in 2030 to meet vehicle electrification targets – about six percent of statewide energy consumption.[li] In order to meet this need, State and municipal governments will have to work closely with utilities across the state to ensure that not only is EV charging infrastructure deployed but that the necessary infrastructure upgrades are made in tandem to ensure reliable charging. Utilities can provide a suite of resources to assist the wide variety of vehicle owners within their service territory.

In recent years the State, in partnership with utilities, has implemented several policies to increase charging infrastructure, highlighted below.

- **Investor-owned Transportation Electrification Planning:** Passed in 2019, the Electric Motor Vehicles Public Utility Services Act (SB 19-077) required Black Hills and Xcel Energy to file transportation electrification plans with the public utilities commission every three years. Xcel received approval for a $110 million Transportation Electrification Plan that dedicates funding to investments in electric vehicle infrastructure, residential charging infrastructure, and helps support the electrification of fleets. The plan also includes specific programs aimed at providing benefits to low-income communities, with $2.2 million for the electrification of buses and $5 million for low-income customer rebates to purchase electric vehicles. In addition to these initiatives, Xcel has also implemented several additional programs that establish partnerships with local dealerships like the Energy EV Dealer Network. The Black Hills Energy Ready Electric Vehicle Plan creates rebates for the installation of electric vehicle charging infrastructure at single and multi-family residences, businesses, and government buildings. The Ready EV plan also establishes customer and dealership outreach and education programs.
- **Municipally- and Cooperatively-owned Transportation Electrification Planning:** Municipal utilities provide about 16 percent of the state's electricity and rural cooperatives provide about 28 percent. Some of these utilities, including Colorado Springs Utilities, Fort Collins Utilities, and Holy Cross Energy, have started to plan and invest in electric vehicle charging infrastructure. For example, Holy Cross Energy has established 113 electric vehicle charging stations and will use data from these chargers to develop programs and rates to reduce the cost of operation and increase grid flexibility and renewable energy penetration. Tri-state has also announced that it will make funding available for rural cooperatives to build out charging stations.

6.4.1 Recommendations

In addition to supporting and ensuring the implementation of the above programs, the State could also implement the following policies:

- Pair fleet advisory services with infrastructure development: It is likely that many public and private fleet operators will convert their fleet slowly over time. Not planning for future electrification could lead a utility to modularly add capacity upgrades for a particular customer— increasing cost and creating additional hurdles for infrastructure development over the long term.
- Introduce flexibility for utilities to finance vehicles and infrastructure: Where the private sector is unwilling or unable to invest, State entities should take action by utilizing existing innovative financing mechanisms like the Colorado Clean Energy Fund – the State's green bank – and by working with State regulators to evaluate the role of the utility in supporting customer ZEV adoption through financing mechanisms like on-bill financing and vehicle to grid models.

- Establish long-term infrastructure build-out plans: Utilities and low- and zero-carbon fuel providers can provide essential insight about fueling infrastructure expansion costs and time requirements.
- Implement effective charging infrastructure rates that incentivize managed charging: The policy impact analysis supporting this roadmap found implementing time of use charging (TOU) can decrease the charging load necessary for EVs by about 40 percent. For example, to meet Colorado's electric vehicle goals in 2030, using TOU charging would increase the peak load by 11 percent compared to a baseline charging scenario that would increase the peak load by 19 percent. Colorado should implement TOU policies to decrease the overall increased demand on the electrical grid.
- Develop equitable electric vehicle programming: Utility transportation electrification programs should take into consideration the impact on low-income customers by developing community-based and multi-family charging infrastructure, car share programs, and by creating electrified multimodal transportation.
- Ensure collaboration between investor-, municipally- and cooperatively-owned utilities: The State should help utilities collaborate to ensure charging infrastructure is being developed thoughtfully throughout the state and is being appropriately supported and funded.

6.5 Education and Outreach

For many drivers, electric vehicles are still not well understood, with many still holding misconceptions around charging needs, reliability, and costs. In 2020, the Colorado Energy Office published an Electric Vehicle Awareness Market Research Report[lii] that had the following key findings:

- Several misconceptions still exist surrounding electric vehicle costs and charging needs: Only 45 percent of Coloradans polled knew of federal electric vehicle tax credits and only 22 percent knew of Colorado tax credits. In the same poll, 70 percent of people thought special charging equipment was required for at home charging of electric vehicles (electric vehicles can be charged through a standard three-prong wall outlet).
- Charging reliability and accessibility are significant concerns for many drivers: The study found many people agree or strongly agree with the following statements: 1) There are not enough public charging stations to own an electric vehicle and 2) Electric vehicles take too long to charge.
- There are regional differences in people's familiarity with electric vehicles, the information they would find helpful, and barriers to purchase: Targeting policies and programs to fit the unique needs of different demographic and socioeconomic groups is important as each community may have unique requirements.

Education and outreach programs can be tailored to overcome these barriers and misconceptions. This will be especially important amongst low- to moderate-income populations that are often even less familiar with electric vehicles than the general population and are not aware of the cost savings associated with electric vehicle ownership. Crafting community specific campaigns, informed by careful stakeholder engagement, to address these outsized information gaps will foster better outcomes and support increased utilization of State incentives and programs to drive electric vehicle adoption.

Since the development of the State's 2020 Colorado Electric Vehicle Plan, the State has implemented several EV communication and outreach programs including developing an EV education and awareness campaign. The campaign is set to launch in 2022 and will be deployed for all market segments and will be hosted and managed on a centralized website that will serve as a go-to resource for all things electric vehicles in Colorado. The centralized website will include inspirational content from the campaign's tentpole moments and first-hand driver stories, with links to resources, guides, and tools, such as a "Find

your EV" explorer tool with functionality to see vehicle specifications, the ability to find local dealership and a referral to an OEM website to learn more.

Additionally, ReCharge Colorado holds electric vehicle workshops and group buys. In FY21, ReCharge Colorado held 76 outreach events, including EV ride-n-drives, and 177 EVs were purchased through its group buy initiatives. ReCharge Colorado also provides services for a variety of groups including consumers, local governments, multi-family housing complexes, and workplaces to identify incentives for EVs and charging infrastructure, like grants or tax credits.[liii] Several regional groups also provide additional education and outreach opportunities focusing on different regions throughout the state. Drive Clean Colorado (formerly Denver Clean Cities Coalition and the Southern Colorado Clean Cities Coalition), Northern Colorado Clean Cities Coalition, CLEER and 4CORE each have a regional focus but work with a variety of stakeholders such as fuel providers, community leaders and vehicle fleets to promote electrified transportation and decrease petroleum use in the transportation sector.[liv,lv,lvi]

6.5.1 Recommendations

In addition to implementing the above education and outreach campaigns, the State should consider implementing the following approaches:

- Establish an EV infrastructure toolkit: The State should provide local and regional governments with an infrastructure toolkit to (1) identify charger options, (2) provide utility contacts for the installation of the supporting electrical equipment, (3) recommend qualified electricians, (4) identify rebates, and (5) detail local permitting requirements.
- Continue to engage with dealerships throughout the state: The State should increase engagement with dealerships and identify resources that can assist dealerships in selling more EVs and can work with used car dealerships to increase awareness of used EV offerings. Dealerships were identified as one of the top five trusted sources for electric vehicle information by the EV Education and Awareness Roadmap.[lvii]
- Increase EV educational opportunities for companies and their employees across the state: The State should provide educational resources for companies to help them identify strategies to increase electric vehicle usage both within their own fleet and with their employees. Discussions should include: 1) offering employee ride and drive events in partnership with local dealerships; 2) company developed incentives for employees to purchase electric vehicles; 3) utilizing company owned electric vehicles for off-site work during work hours.

Increasing Engagement – Pueblo County's Electric Vehicle Roadmap

Pueblo County, through the development of its Electric Vehicle Roadmap, has identified several outreach programs it plans to develop to make electric vehicle adoption easily accessible, dispel misconceptions, and encourage more equitable electric vehicle adoption, outlined below.

Electric Vehicle Website: A specific website that holds all information and resources about electric vehicles including charging station locations and types, permitting guidance, building codes, local and State incentives, and future EV projects.

Media Campaign: Build an electric vehicle awareness and engagement campaign with the public by using consistent messaging and branding using both social media and traditional media.

Surveys: Public surveys can be distributed via mail or online and are an excellent way to understand public perceptions and misconceptions.

Public Meetings: Local government hosted public meetings or town halls enables community members to discuss electric vehicles with local experts. Local governments can also attend other community events or hold pop-up tents in high-trafficked areas.

Comment Maps: A comment map allows a member of the public to "pin" a comment to a specific location across the community. This pin can be used as a tool to gather information on questions, comments, or concerns that the public may have regarding electric vehicle charging stations.

These forms of communication can be an easily accessible and inclusive way to reach residents and engage them in the electric vehicle transition.

6.6 Emerging Technologies and Innovation

While this Roadmap focuses on the development of a light-duty electric vehicle market that will allow the State to reach its electrification goals, the future of transportation will depend on a wide variety of technology innovations that will change the way drivers operate and fuel their vehicles.

6.6.1 Hydrogen Fuel Cell Vehicles

In October 2021, the Colorado Energy Office published a Low-Carbon Hydrogen Roadmap analysis that evaluated the role of hydrogen in achieving the goals set within the State's GHG Roadmap which identified hydrogen as a potentially important low-carbon fuel beyond 2030, especially to reduce emissions in hard-to-electrify sectors.[lviii]

The analysis concluded that, while there is tremendous potential for hydrogen to play a role in the State's decarbonization strategy, including within the transportation sector, fuel cell vehicles are likely to play a much more significant role within the medium- and heavy-duty vehicle sector than within the light-duty vehicle sector. Specifically, the report found that in terms of logistics and economics, heavy-duty trucking offers the most likely opportunity for hydrogen fueled vehicles within the state.

While it is possible that hydrogen will have a more outsized impact on other parts of the transportation sector, the hydrogen market is still nascent and will need to be developed further before it is possible to discern what type of impact fuel cell vehicles will have on light-duty vehicle decarbonization. For hydrogen to reach its potential as a decarbonized fuel, it will be important for State leadership to fund and partner with public and private entities throughout the state to incentivize and support the development of a low-

carbon hydrogen market. The State has already begun to develop some of these important market creation elements.

For example, in 2019, the State legislature passed HB 19-1159 which clarified that alternative fuel motor vehicle tax credits include hydrogen fuel cell vehicles. SB 21-260 also provides $5.3 billion for sustainable transportation, including hydrogen refueling stations.

6.6.2 Autonomous Vehicle Development

Autonomous vehicles (AVs), like hydrogen fuel cell vehicles, have the potential to fundamentally change the transportation market, increasing mobility options for community members throughout the state, especially elderly and disabled populations. While the opportunity is significant, so too is the potential environmental risk if AVs are developed in such a way that increases congestion, commute times, VMT and additional urban sprawl.

The State of California, in an effort to ensure that AV technology developments do not cause negative environmental impacts, has developed a set of automated vehicle principles for healthy and sustainable communities that focus on aligning AV development with the following established state environmental and community goals: 1) shared use vehicles as an alternative to personal ownership; 2) maximizing ride-sharing trips by encouraging trip pooling; 3) maximize deployment of AVs as low- or zero-emission vehicles; 4) promote use of vehicles that are right-sized for trip purposes; 5) part of an efficient multimodal system that transports people and goods to destinations quickly and efficiently and that is energy and space efficient; 6) efficient land use that does not encourage sprawl; 7) prioritized complete and livable streets; and, 8) improves affordable access to destinations particularly among low-income and disproportionately impacted communities.[lix]

Implementing a similar set of principles could help to ensure that new technology development does not create additional environmental barriers.

6.7 Additional Considerations to Increase Electric Vehicle Affordability, Ease of Adoption, and Market Development

As the State of Colorado looks to develop this roadmap of near-, medium-, and long-term actions that will put the State on the path to achieving its transportation electrification goals, evaluating which policies will have the largest impact and when they should be deployed will be important to consider especially when funding resources are limited.

Throughout the stakeholder engagement sessions that informed this work, stakeholders repeatedly highlighted the importance of developing a transportation sector that is lower emitting and that includes a combination of high efficiency personal vehicles and for the State of Colorado. That will include a significant amount of vehicle electrification which will require increased communication and outreach, incentives to drive down the cost of vehicles and chargers, and thoughtful leadership from the State to collaborate with a wide variety of stakeholders to ensure that charging infrastructure is deployed and maintained and that the benefits of vehicle electrification are communicated through a wide variety of platforms in communities throughout the state.

The policies and programs highlighted below are designed to address many of the elements described above focusing primarily on increasing affordability and accessibility and to develop a more robust light-duty electric vehicle market. The evaluation of each of these policies and programs, paired with the scenarios modeled within this report, ultimately led to the development of the key policy priorities highlighted within the Roadmap section of this report.

6.7.1 Increasing Affordability

Increasing the affordability of electric vehicles and chargers will continue to be an important near-term policy approach to lowering the upfront costs of electric vehicles until they reach price parity. The following incentive programs have been highlighted as important near-term actions that the State should develop or continue to support.

6.7.1.1 Vehicle Programs that Support the Replacement of High-Emitting Vehicles for Low and Moderate Income Coloradans

Vehicle replacement programs encourage faster fleet turnover by providing incentives for consumers to retire older, less efficient vehicles with newer, more efficient models. Many federal funding programs, as well as the VW Settlement program, include a scrap and replace requirement for funding. One of the benefits to implementing a vehicle replacement program is that it not only incentivizes vehicle owners to trade in their older, more polluting vehicles for new low- or zero-emission vehicles, but it also has the benefit of removing older ICE vehicles from secondary and tertiary vehicle markets. Since being broadly implemented, studies have shown that vehicle replacement programs are more effective in high polluting urban areas where the air pollution is more significant (e.g., the Denver Metro / North Front Range Ozone nonattainment area). Additionally, urban areas are likely to have better access to other forms of transportation and other complementary policies (e.g., low emission zones, described below) which have also been shown to increase program effectiveness.[lx]

Colorado has previously implemented programs that offered vehicle replacement. The ALT Fuels Colorado program for example provides incentives to scrap pre-2009 medium- and heavy-duty vehicles and replace them with electric vehicles or recovered methane fleets.[lxi]

The State could implement a larger new light-duty vehicle replacement program designed to encourage more rapid ICE vehicle replacement with electric vehicles, in accordance with SB 21-260 24-38.5-303(8)(c). The following key elements should be included in the program design to ensure an effective and equitable replacement program is developed.[lxii]

- Replacement vehicles need to be as clean as possible (e.g., ZEVs), replacing older vehicles with new ones that meet more stringent emission standards and have better fuel economy.
- Provide tiered incentives based on income eligibility.
- Offer different trade-in options for vehicle owners (e.g., vouchers for an e-bike or multi-year transit pass) in addition to offering vouchers for zero-emission vehicles.
- Governments should consider implementing complementary policies with additional incentives such as low emission zones.

6.7.1.2 Tax credits and Rebates

Tax credits are another mechanism to alleviate the high cost of electric vehicles. The State of Colorado has one of the highest State tax credits for EVs in the nation, passing HB 19-1159 which extended and modified the innovative motor vehicles tax credit which is currently $2,000 through 2026.[lxiii] Importantly, the tax credits were modified to allow TNCs like Lyft and Uber drivers to receive a larger tax credit for offering leased electric vehicles that are made available through a weekly rental program.[lxiv]

While tax credits have proven to be an important tool to increase electric vehicle adoption[lxv], for low-to-moderate income residents in both rural and urban communities, the high upfront costs and lack of financing options to purchase new vehicles remain even when tax credits are available. Rebates provide another mechanism to reduce the vehicle prices and can be offered at or after the point of sale. Point-of-

sale rebates reduce the purchase price of a vehicle at the point it is purchased as a “cash on the hood” deal.

As the State considers extending current tax credits and rebates it should coordinate with local and municipal governments and utilities to ensure that consumers can easily find information on each of the incentive programs that are available to them (For more information on additional communication strategies see Section 6.5).

6.7.2 Ease of Adoption

Increasing the accessibility of vehicles and chargers is another essential near- and medium-term strategy to increasing light-duty electric vehicle adoption. This includes not only developing an electric vehicle charging infrastructure development process that includes streamlined permitting and effective building code requirements but also includes increased communication and education on electric vehicles (e.g., what incentives are available, how charging works and where charging infrastructure exists).

6.7.2.1 Creating a system that supports the development of EVSE

Developing electric vehicle infrastructure within the state should include the creation of a streamlined system that encourages the deployment of EVSE in a comprehensive way that increases reliability and ensures confidence in consumers that there is ample charging infrastructure to meet their needs. In Colorado, as in many other home rule states across the country, local buy-in and action at the individual municipality and county-level will be essential to deploying many of the policies described below.

Developing Electric Vehicle Ready Building Codes

Adding charging infrastructure during construction or major building renovations/expansions can bring down charger installation costs significantly compared to building retrofits.[lxvi] Boulder, Denver, Fort Collins, Aspen, and Summit County among other municipalities have put in place EVSE-installed, EV-ready (conduit, electric panel capacity, wiring, and outlet/termination point), and EV-capable (conduit and electric panel capacity) commercial, multi-family, and residential building code requirements.

In May 2019, Colorado passed HB 19-1260 which requires local jurisdictions to adopt one of the three most recent versions of the International Energy Conservation Code (IECC) for new buildings. The State has also created an Energy Code Adoption Toolkit and a Code Helpline to assist jurisdictions in their adoption of new energy codes including providing guidance on how to adopt EV-ready building codes.[lxvii,lxviii]

In addition to supporting the implementation of the above programs, the State should continue to encourage and support local governments throughout the state to implement EV-Ready building codes in new developments and evaluate ways to work with municipalities and building owners to finance electric vehicle building retrofit programs for existing buildings.[lxix]

Additional Perspectives – Local Governments Implementing EV Friendly Building Codes

Many local governments have enacted requirements to make their jurisdictions more EV-friendly. Some governments require pre-wiring to making parking areas EV-ready, others require the installation of charging ports. Several examples are highlighted below:

- The City and County of Denver requires at least one EV-ready parking space per dwelling unit in single-family homes; 5 percent EV-installed, 15 percent EV-Ready, and 80 percent EV-capable for multi-family homes; and 5 percent EV-installed, 10 percent EV-Ready, and 10 percent EV-capable for commercial properties. The City also has EV readiness requirements that apply to major renovations and expansions of buildings.
- The City of Boulder requires at least one EV-ready parking space per dwelling unit in single family homes; 5 percent EV-installed, 15 percent EV-Ready, and 40 percent EV-capable for multi-family homes with over 25 spaces; and 5 percent EV-installed, 10 percent EV-Ready, and 10 percent EV-capable for commercial properties.
- Summit County requires at least one EV-ready parking space per dwelling unit in single family homes; 5 percent EV-installed, 10 percent EV-Ready, and 40 percent EV-capable for multi-family homes with over 10 spaces; and 5 percent EV-installed, 10 percent EV-Ready, and 40 percent EV-capable for commercial properties with over 25 spaces.

Engagement with Dealerships

While dealerships have been identified as a potential outlet for electric vehicle education by organizations such as Plug In America, there is still work to be done in electric vehicle dealership engagement.[lxx] While electric vehicles can be purchased outside of the dealership model, due to the passage of SB 20-167 which allows electric vehicle only manufacturers to sell directly to consumers, most vehicles are still purchased using the dealership model, though the market for online vehicle purchases has increased.[lxxi] The State should continue to work directly with dealerships across the state and online vehicle marketplaces, in addition to and in partnership with utility programming, to identify pain points, and develop resources that help dealerships and online marketplaces sell more EVs.

Streamlining Site Development

Several stakeholders who participated in the development of this roadmap highlighted that more streamlined and effective site development and EVSE incentive and grant processes are needed within the state to increase the rate of charging infrastructure development and to lower the costs associated with siting and permitting processes. A report recently published by EVgo highlights several best practices in charging infrastructure development. A few of those recommendations are highlighted below:[lxxii]

- **Deploy funding for electric vehicle chargers quickly with multiple rounds:** Charge Ahead Colorado has already deployed this strategy by having three solicitations per year at the same times each year, thereby creating predictable development cycles.
- **Evaluate charger locations with a transparent scoring rubric:** By utilizing a set of criteria (e.g., traffic density, distance to existing DCFC, and equity measures). Instead of determining site locations by distance from main arterials, the State and municipal governments would be better able to choose location that meets broader policy objectives.

- **Commit to EVSE grant program timelines and allow for public input and program flexibility:** Ensuring that there is clear communication at the beginning of a program will allow key stakeholders to know what expectations have been set so that they can better plan for charger installation timeframes.
- **Work with utilities to streamline their internal and external planning processes to ensure that grid connections are seamless and do not delay charger development:** The State can play a meaningful role in working with utilities to make easement and capacity maps readily available to providers and can work with the State's regulatory bodies to ensure that utilities are able to dedicate State and other resources deploying effective charging infrastructure programming.
- **Expedite permitting processes:** The State should work with local governments to expedite the EVSE permitting process by creating a standardized permit review form that streamlines make-ready infrastructure development and removes unnecessary permitting requirements (e.g., pre-approvals) that municipalities could adopt.

6.7.2.2 Implementing Zero Emission Vehicle Zones

Zero emission zone (ZEZ) and low emission zone (LEZ) policies can have a large impact in high activity, high population density areas where emissions exposure is significant (e.g., city centers, dense residential areas, etc.). The impact of the policies depends heavily on how it is implemented, with some studies showing limited emissions reductions if the zone is too small or not implemented in tandem with other policies that support disproportionately impacted communities and limit emissions leakage out of the low or zero emissions zone.[lxxiii]

Studies note that LEZ policies are not as effective without greater access to affordable and convenient transportation alternatives.[lxxiv] Additional policies (e.g., increasing public transport options, providing exemptions for residents living within the zone, supporting pricing schemes that support low-income households) should be implemented in combination with LEZ to ensure that ZEZ and LEZ policies do not disproportionately burden low-income communities, small businesses, and residents who live within a LEZ or ZEZ. It is critical that low-income residents/businesses have a say in determining which equity policies are combined with the ZEZ and LEZ (e.g., low-income exemptions, revenue invested in EV fleet conversion, etc.). Additionally, cities should consider equitable forms of implementation and enforcement by allowing communities to be part of the implementation process to avoid inequitable and potentially harmful enforcement practices that could lead to over-policing or hyper-surveillance of people of color. It is important to monitor the impacts of the policy both within and outside the ZEZ and LEZ as people in adjacent areas may realize an increased impact from LEZ.

While the implementation of this policy would likely take place at the local or regional level, the State will need to evaluate if developing this type of ZEZ or LEZ would require enabling legislation.[lxxv]

6.7.3 Market Development

The transformation of the transportation sector to a more sustainable and lower-emitting system will require the development of market creating policies. While the development of each of the below policies would take place over the longer-term, each should be evaluated as **near- to mid-term policies** to account for regulatory and legislative requirements.

6.7.3.1 LEV and ZEV standard updates and rulemakings

In 2018, Colorado adopted the Colorado Low Emission Automobile Regulation (CLEAR), which sets emission requirements for new light-duty and medium-duty vehicles sold within the state starting with MY

2022.[lxxvi] In 2019, Colorado adopted a Zero Emission Vehicle standard that requires auto manufacturers to sell over 5 percent ZEVs by MY 2023 and over 6 percent ZEVs by My 2025.[lxxvii]

The California Air Resources Board (CARB) is currently working to update the Advanced Clean Cars regulation (ACC II) to increase stringency, better align standards with real-world reductions (e.g., better control of engine start emissions that can exceed lab test emissions), and improve the ZEV experience for consumers (e.g., standardizing fast charging ports).[lxxviii] Standards will align with the CA statewide goal of 100 percent ZEV sales by 2035.[lxxix] A final rulemaking package is expected to be presented to CARB in June of 2022 with final adoption at the end of the year.[lxxx]

The State of Colorado should consider adopting ACC II if the State of California adopts the new regulation. These requirements would put the State on a path to ensuring that 100 percent new light-duty vehicles sold are zero-emitting by 2035 and would follow the recent announcements of three other governors implementing a similar 100 percent sales target:

- First, in September 2020, California Governor Gavin Newsom issued an executive order that set a goal that 100 percent of in-state sales of new light-duty passenger cars and trucks be zero-emission by 2035, directing the Air Resources Board to develop and propose regulations consistent with meeting that goal.[lxxxi] The California ZEV Market Development Strategy implementation framework focuses four key elements: infrastructure as a market enabler, investing in equitable access to public charging and hydrogen fueling stations; changing behavior, making the transition as convenient as possible by bolstering technology, charging, and fueling reliability and user confidence; scale, increasing investor confidence by filling market gaps with long-term public funding; and building the EV market in California. Further cementing this commitment, Governor Newsom's 2021 budget includes $1.5 billion for ZEVs and supporting infrastructure.[lxxxii]
- In December 2020, Governor Charlie Baker committed Massachusetts to the same targets, affirmed in the Clean Energy and Climate Plan for 2030: "[California's Advanced Clean Cars II (ACC II)] will require ZEV sales to ramp up to 100 percent of new LDV sales by 2035. Once finalized, MassDEP will adopt and implement these new ACC II regulations".[lxxxiii]
- In September 2021, New York Governor Kathy Hochul signed A.4302/S.2758 which sets a goal for all new passenger vehicles and off-road vehicles and equipment sold in New York State to be zero-emission vehicles by 2035.[lxxxiv] New Jersey is considering a similar path as the New Jersey Department of Environmental Protection proposed a ban on fossil fuel vehicle sales by 2035 in part of an official road map to bring the State's carbon dioxide (CO_2) emissions down by 80 percent by 2050.[lxxxv]

6.7.3.2 Low Carbon Fuels Standards

Low carbon fuel standards have been shown to play a valuable role in offsetting the cost of zero- and low-emitting vehicles and EVSE infrastructure in states like California and Oregon. CEO's LCFS Feasibility Study found that, if implemented, the funds generated by an LCFS program could have a meaningful impact on the funding available for ZEV fueling infrastructure or other programs that would increase electric vehicle adoption.[lxxxvi] Colorado's Low Carbon Fuel Standard (LCFS) Feasibility Study found that a 10 percent carbon intensity reduction is feasible within 10 years if an LCFS policy were to be adopted. Reducing the carbon intensity of fuel will come from LCFS price signals to increase the blending of biodiesel, renewable diesel, and reducing overall carbon intensity fuels over time. Electric vehicle and alternative vehicle adoption would play an important role in a LCFS program.[lxxxvii] However there are still a few areas that would benefit from additional evaluation such as the potential of double-counting of emissions reductions from other light duty electrification efforts and the appropriate use of biofuels.[lxxxviii]

6.7.3.3 Cap-and-Invest programs

Cap-and-invest policies set an overall declining cap on emissions from a defined group of sources and gases. Within cap-and-invest policies, the majority of the proceeds developed from program actions are invested back into programs that support greater emissions reductions within the targeted sector. Several states and regions have implemented cap-and-invest policies and since implementation, these policies have provided a significant source of revenue that has been distributed into programs that have increased efficiency and reduced emissions.

The Polis administration has adopted a sector-based approach to GHG reduction that does not incorporate cap-and-invest or cap-and-trade programs, due to concerns about their complexity, their potential to exacerbate environmental injustice, and their political divisiveness. Thus, while this report includes these policies for completeness, this is unlikely to be a component of Colorado's policy approach.

6.8 Planning for Transportation Electrification

State leadership, planning, and coordination will be essential to ensuring that the policy and program recommendations described throughout this section are developed thoughtfully and with communities throughout the state in mind. This report represents one of many planning documents designed to keep the State on track to meeting its GHG emissions reduction goals and was developed with the thoughtful guidance of State officials, members of the public, and key stakeholders identified through the Colorado Electric Vehicle Coalition (CEVC). While the State needs to continue to develop and support these planning processes, it will be critical that these planning approaches are constantly evolving and improving in productive and thoughtful ways that incorporate the feedback of a growing number of Coloradans from across the state.

6.8.1 Recommendations

As the State continues to improve upon its electric vehicle planning processes it should keep the following recommendations in mind.

- **Ensure sustained engagement of leaders and community members in disproportionately impacted communities at every stage of the planning process:** This can help ensure that the process: 1) includes comprehensive, insightful documentation of existing conditions; 2) considers socioeconomic and health conditions and develops strong partnerships between public health and planning; and, 3) measures projected health impacts of scenarios.[lxxxix] Colorado is developing best practices for meaningful engagement, including the development of a climate equity framework and an EV equity study. Additionally, after being signed into law in July 2021 by Governor Polis, HB 1266 created a new environmental justice ombudsman role who reports to the director of CDPHE as well as an advisory board within the Department.
- **Continue to Collaborate Regionally:** The State is already an active member of several initiatives designed to encourage regional electrification including its participation in developing a Regional Electric Vehicle Plan for the West (REV West), which has led to the development of more than 100 DCFC stations with another 75 stations in the planning phase.[xc, 13] The State should continue to support the development of interstate planning corridors and should also work to connect communities and regions within the state.

[13] The regional EV corridor will include the following interstates: Interstates 8, 10, 15, 17, 19, 40 in Arizona; Interstates 25, 70 and 76 in Colorado; Interstates 15, 84, 86, and 90 in Idaho; Interstates 15, 90 and 94 in Montana; Interstates 15 and 80 in Nevada; Interstates 10, 25 and 40 in New Mexico; Interstates 15, 70, 80 and 84 in Utah; and Interstates 25, 80 and 90 in Wyoming.

- **Continue to engage and coordinate with key stakeholders across the vehicle value chain:** State entities should work with utilities, fleet operators, EVSE providers, and OEMs to ensure coordinated infrastructure buildout. Providing a space for utilities, fleet operators, State entities, and vehicle manufacturers to share their distinct and critical expertise will be essential to ensuring that infrastructure buildout is coordinated, and plans are factoring in all critical information.

6.9 Just Transition

As the State moves towards a zero-carbon transportation future it must ensure that no community is left behind in the transition including both disproportionately impacted communities and those with a high percentage of oil and gas workers. There are several actions that the State can take to support the growing electric vehicle supply chain and to enable the transition of workers from the ICE vehicle supply chain. A few key recommendations are outlined below.

- **Develop statewide workforce ZEV training program:** Colorado can work with public universities, community colleges, and technical schools to develop workforce training and career programs for new workers and support the existing workforce with on-the-job training.
- **Develop electric vehicle training supply chain for the state:** Increase vocational training for electric vehicle technicians and electrical workers to ensure electric vehicle and charger maintenance skills are available in rural and urban communities. State and local governments should provide grant funds for community colleges, technical schools, and universities that engage in workforce development programs for electric vehicle technicians and electricians.
- **Provide funding for job training for former oil and gas workers:** Many of the jobs that will be created by the clean energy transition require the expertise of the existing fossil fuel workforce. The State should provide funding opportunities for job training in clean energy and transportation electrification fields for current oil and gas workers to create a just transition for workers and to fill vital jobs in the clean energy economy.
- **Increase outreach and communication on potential job offerings:** The State should ensure training programs are appropriately communicated. Programs at community colleges cater to many different types of students with some students learning the trade for the first time and others looking for re-training opportunities. Making sure these offerings are well known and supported will be important for encouraging enrollment.
- **Support a wide variety of workforce development programs:** In addition to developing a workforce of technicians and engineers to support ZEVs, electricians must simultaneously be trained to support the growing ecosystem of chargers. For example, a collaboration of EVSE providers, OEMs, utilities, and other ZEV stakeholders launched the Electric Vehicle Infrastructure Training Program (EVITP) in 2011.[xci] To date, the program has certified over 4,000 electricians in the proper installation of EVSE equipment after completing approximately 20 hours of training and a two-hour certification exam. Beyond partnerships with community colleges, EVITP has also worked with other accredited institutions and utility service centers.
- **Convene key stakeholders to discuss key gas vehicle transition pain points:** The State should convene stakeholders across the entire oil and gas supply chain (from oil and gas producers to convenience store owners) to evaluate and better understand the types of programs and policies that may best support their transition to a low-carbon economy (e.g., workforce training, relocation funding, etc.).

7. POLICY IMPACT ANALYSIS

A number of policies, programs, strategies, and factors (hereafter collectively referred to as 'policies') have been identified earlier that individually and in combination can be useful towards achieving Colorado's goal of having 100 percent of the in-use light-duty vehicles (LDV) be electrified by 2050 (100 x 50). In reviewing available research, initiatives, and programs undertaken by other states, several policies were identified to be leaders in achieving the 100 x 50 goals or meaningful enough to warrant further investigation.

Modeling Outputs

The STEP Tool and Toolkit for Advanced Transportation Policies yields several key metrics to evaluate different policy combinations. They are:

- Projected number of in-use ZEVs;
- Changes in electricity use and load from ZEV charging;
- Projected fuel savings;
- GHG and air quality benefits;
- Financial impacts to utility customers because of increased electricity sales; and
- Projected financial impacts of owning an EV vs. ICE vehicle for Colorado drivers.

Note: all costs and financial benefits are presented as 2020 dollars (2020$)

This section summarizes the results of a modeling exercise study that addresses the impacts and co-benefits of a combination of policies. The ERM proprietary STate Emissions Pathway (STEP) Tool and Toolkit for Advanced Transportation Policies were used to model net benefits and costs of certain policies. This model is not a vehicle choice model, and policies were evaluated with the greatest rigor possible utilizing data from the application of similar policies in other contexts, but the results should be interpreted with caution, as the model is not set up to evaluate the interactions of multiple policies and programs. To evaluate the results of different policies, a set of three individual scenarios were developed and modeled and then compared against a baseline scenario. The baseline scenario follows a trajectory based on annual ZEV[14] sales projections from the Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2021 and is intended to illustrate what would happen if the State were not undertaking any of its current policies. This scenario maintains significant levels of ICE vehicles through 2050.

7.1 Achieving Colorado ZEV Targets

The modeled scenarios each have different ZEV sales trajectories and overall ZEV penetration levels between 2020 and 2050 (Figures 2 and 3) and are characterized as follows:

- CO GHG Roadmap: This scenario is meant to illustrate the State's current policies, programs, and investments. ZEV sales occur between now and 2030 at a rate that meets the Colorado goal of having 940,000 EVs on the road by 2030. After 2030, sales growth occurs at a rate of 0.75 percent above the prior year sales[15]. By 2050, 80 percent of in-use passenger cars and light trucks will be EVs.
- Advanced Clean Cars II: This scenario includes current Colorado EV policies and programs and considers if Colorado were to adopt the California Advanced Clean Cars II (ACC II) proposed rule as

[14] ZEVs, for the purposes of this analysis, include battery-electric vehicles (BEV) and plug-in hybrid vehicles (PHEV). Although fuel-cell electric vehicles are considered ZEVs, they were not evaluated. This analysis focused on light-duty passenger vehicles and light trucks. Non-road vehicles were not evaluated as part of this analysis.

[15] Based on light duty sales projections in EIA's AEO 2021, Table 38.8 (Mountain Region). Includes both hybrid and full battery electric vehicle sales after 2030.

of fall 2021 that would mandate manufacturer sales quotas after model year 2025.[16] Using this framework, 100 percent of all passenger cars and light trucks sold in Colorado would be ZEV by 2035. By 2050, 99.6 percent of in-use passenger cars and light trucks will be EVs. While not explicitly modeled in this scenario, additional supportive policies and programs would likely need to continue or be developed beyond 2030 to complement this regulatory approach.

- 100 x 50: This scenario includes current Colorado EV policies and programs, and also meets the 100 x 50 goal, but relies on a different set of policies than ACC II. This scenario uses the same assumptions as the CO GHG Roadmap through 2025. Afterwards, ZEV sales are influenced by the four potential illustrative policy actions listed below. More study is needed to understand if these policies could collectively result in reaching the State's light-duty vehicle goals, or whether a different mix of policies may be needed.
  - Light-Duty Fleet Rule: light-duty fleets larger than 90 vehicles would be required to meet a 100 percent ZEV mandate by 2030.
  - Transportation Network Company Requirement: Requires 90 percent of TNC mileage to be provided by ZEVs after 2030.
  - Light-Duty EV Incentive Program: Colorado begins a new tax incentive for ZEV purchases starting in 2026 and running through 2037.
  - Light-Duty Vehicle Replacement Program: Colorado would implement a large new incentive program to scrap older vehicles for a new EV from 2025 through 2033. Some details regarding a potential replacement program include:
    - The timeframe is assumed to begin immediately after the current Zero Emission Vehicle Tax Credits (Income 69) program sunsets at the end of 2025.
    - Results in an incremental increase of 11.2 percent of passenger cars and 14 percent of light truck sales being ZEV (2026-2033).[17]
    - The incentive assumes passenger cars will receive $5,000 and light trucks $8,500 between 2026 and 2033 and this will result in scrapping of a combined 274,555 vehicles at a projected cost of $1.64 billion.
  - Light-Duty EV Incentive Program: Colorado would extend and amend its tax incentive for EV purchases starting in 2026 and running through 2037.

In conducting this analysis, distinction was made between passenger cars and light trucks, although both are included within the LDV EV strategies discussed. For benefit of interpretation, this analysis broadly defines passenger cars and light trucks as follows:

- Passenger car: cars and small/medium cross-over utility vehicles (CUV) and sport utility vehicles (SUV) with a uni-body construction.
- Light truck: larger SUVs and pickup trucks with a GVWR less than 8,500 lb and a body-on-frame construction.

[16] In Spring 2022 the proposal changed substantially for the 2026-2030 timeframe. The modeling has not been updated to reflect this change.

[17] Although there are more passenger cars than light trucks in the Colorado fleet, registration data suggests that light trucks remain in the fleet for longer periods of time. These sales contributions are based on an anticipated likelihood that with more product offerings turnover of light trucks will ramp up as compared to passenger cars, which will have a more robust market prior to implementation of the vehicle replacement program.

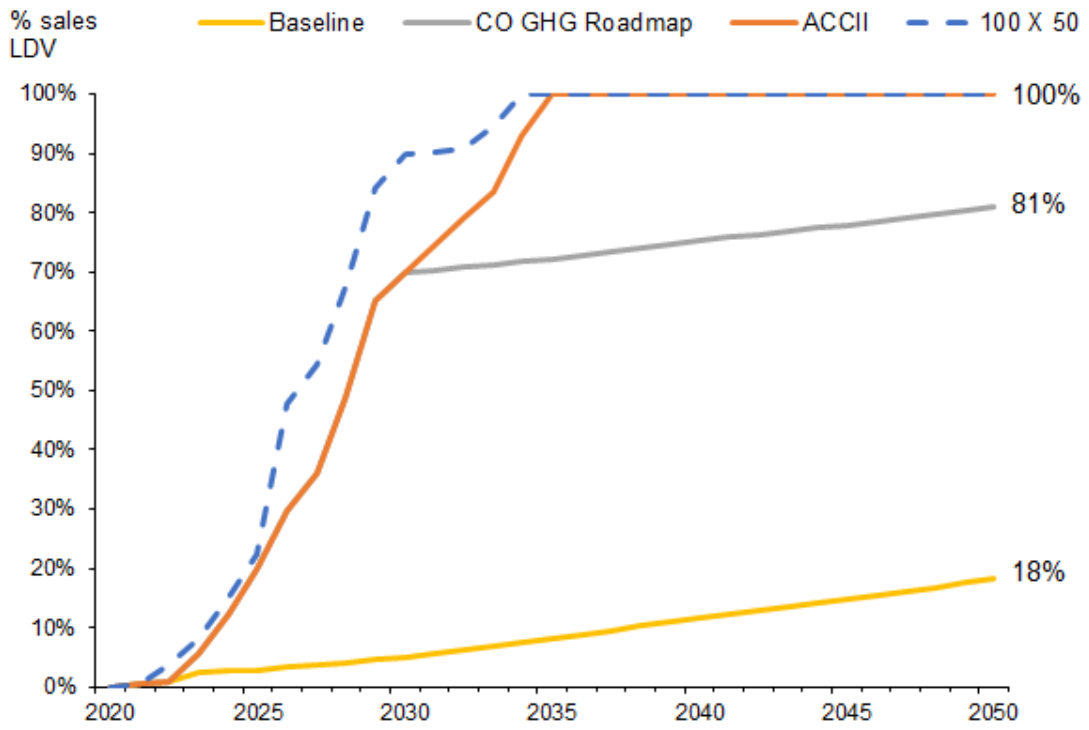


Figure 2: Comparison of ZEV Sales Trajectories for Different Policy Standards

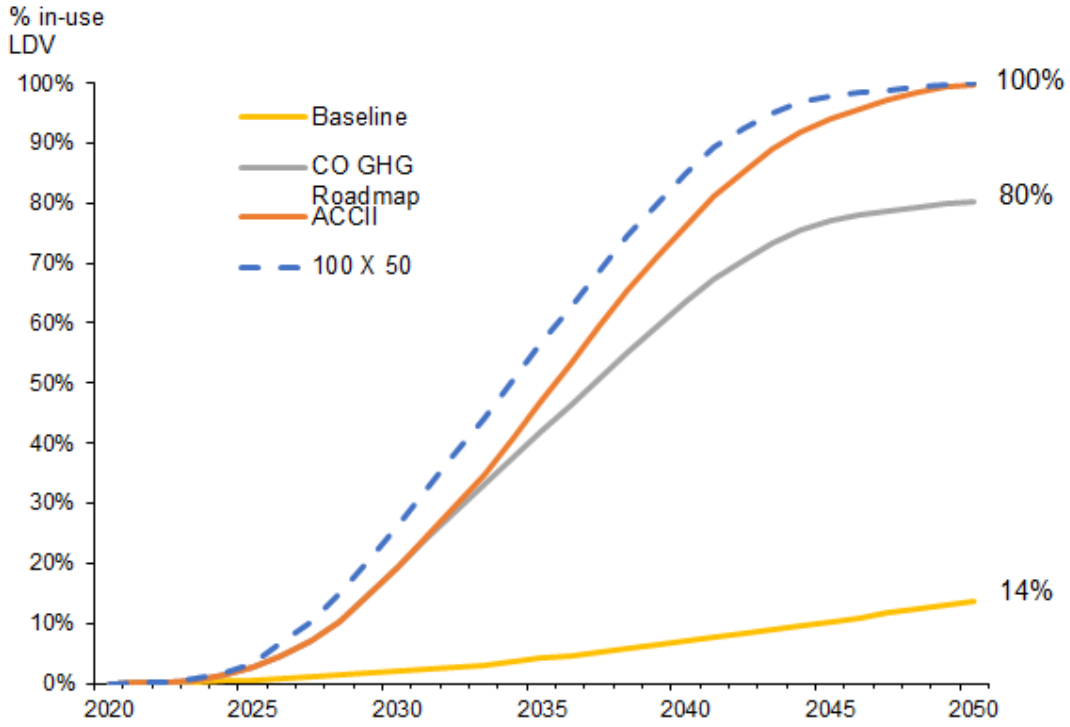


Figure 3: Comparison of Light-Duty ZEV Penetration Scenarios

The penetration levels for each scenario (Figure 3 and Table 8) show that only the 100 x 50 scenario meets the goal of having 100 percent of all in-use light-duty vehicles be EV by 2050. However, the ACC II scenario comes very close, with a projected 99.6 percent of in-use EV LDVs. Figures 4-6 further break down the EV penetration results and illustrate the estimated total number of electric LDVs split by passenger cars and light trucks for each modeled scenario.

Table 8 summarizes the estimated number of in-use EVs at 10-year increments between 2030 and 2050.

Table 8: LD EVs In-Use by Scenario

Year	Baseline	CO GHG Roadmap	ACC II	100 x 50
2030	96,284	940,000	940,000	1.3 million
2040	398,921	3.6 million	4.3 million	4.8 million
2050	892,000	5.2 million	6.4 million	6.5 million

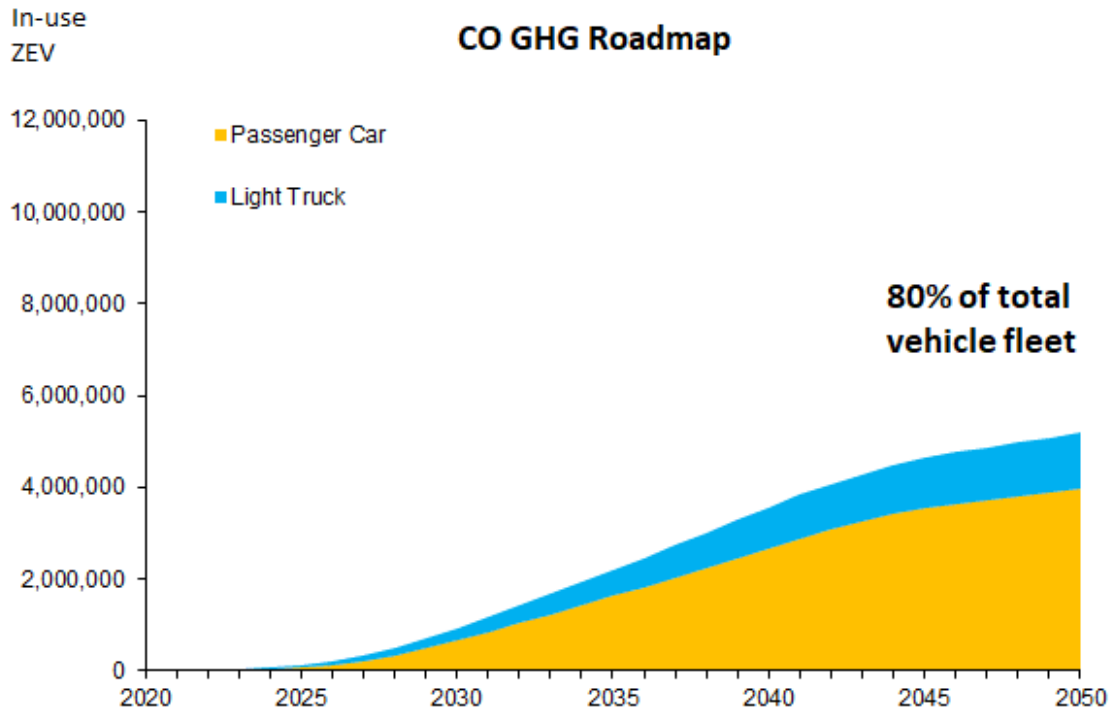


Figure 4: Projected Colorado In-Use Fleet – CO GHG Roadmap Scenario

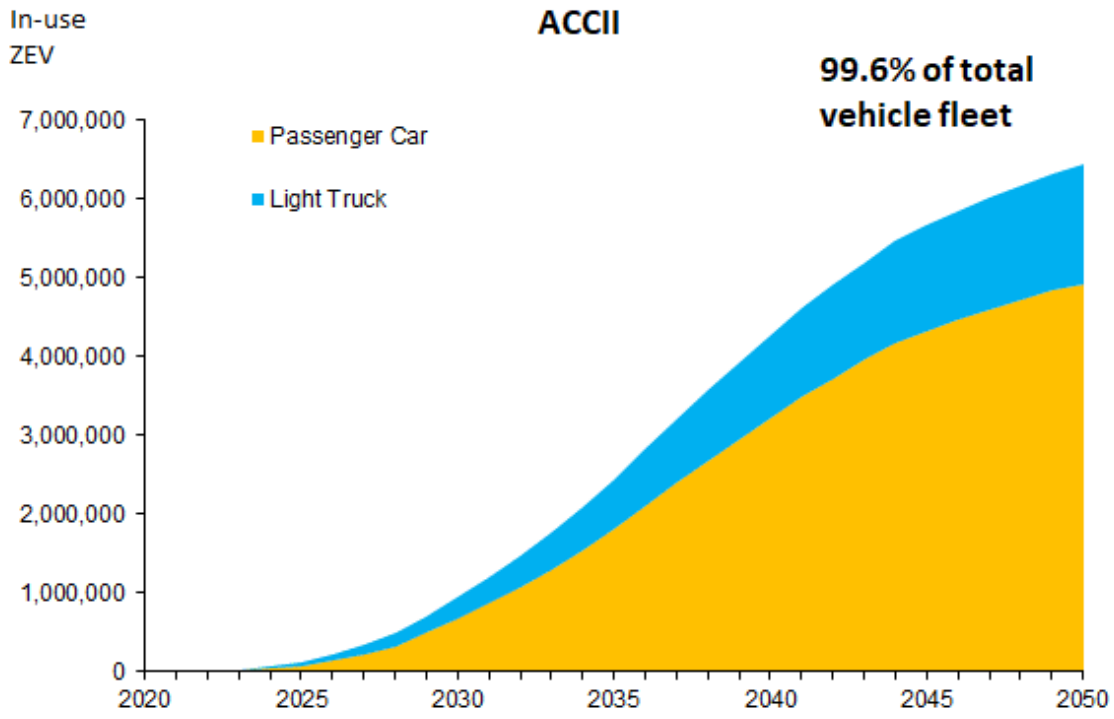


Figure 5: Projected Colorado In-Use Fleet – ACC II Scenario

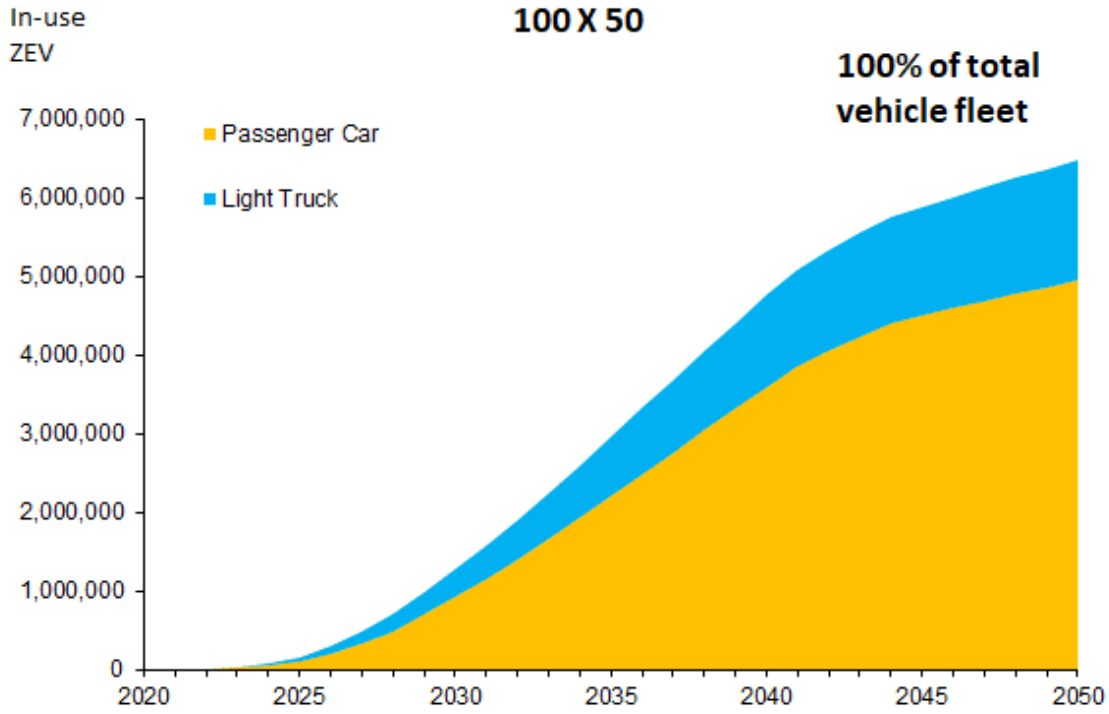


Figure 6: Projected Colorado In-Use Fleet – 100 x 50 Scenario

7.2 Infrastructure Impacts

7.2.1 Impact on ICE Infrastructure

An acknowledged future impact of moving away from ICE vehicles will be the declining need for ICE vehicle supporting infrastructure (e.g., gas stations, refineries, etc.). Figure 3 above can also be interpreted in the context of when ZEV usage begins to significantly offset ICE vehicles and therefore the need for ICE vehicle supporting infrastructure. Among the three modeled scenarios, each is in the vicinity of ZEVs making up approximately 50 percent of in-use vehicles by 2035-2040, assisted in part by the anticipation that by 2032, BEV200 will reach cost parity with ICE vehicles (on a purchase price only basis for a BEV200).[18]

Another consideration regarding the need for ICE infrastructure is in supporting PHEV. A cost-parity differential between PHEV and BEV is expected to widen as a PHEV introduces a trade-off of integrating both BEV and ICE technology into the vehicle platform. Globally between now and 2030 BEV sales are expected to far outperform PHEV.[xcii] Additionally, PHEVs are coming under increased scrutiny by market watchers and governmental organizations over concerns that PHEVs are relying much less on their batteries and more on the ICE and therefore should be phased out.[xciii,xciv]

The impact can be posited to begin with a period with little impact, particularly in urban areas, as the number of ICE and PHEV vehicles will still support a majority of stations as they exist today; however, with an anticipated rapid decline in localized infrastructure after 2040 as it may be untenable to maintain a fueling station that relies solely on gasoline and diesel. What may occur is the conversion of these stations to EV charging hubs and other diversified use facilities.

The modeling exercise did not contemplate the economic impact of declining need for ICE infrastructure. It is presented here as an acknowledgement that there will be a period when ICE infrastructure needs decline, potentially rapidly, and that appropriate economic, development, and land use planning exercises will be necessary.

7.2.2 Electric Infrastructure Needs

Each of the modeled scenarios is estimated to require different infrastructure needs and installation schedules as 2050 approaches. The STEP Tool estimates both home and public charging needs for each scenario as well as a projected necessary investment.[19] Home infrastructure costs are assumed to be borne by individual vehicle owners and fleets – both public and private. The model also assumes that public charger networks are required and built-out to ensure adequate charging of the ZEV fleet. A key assumption of the analysis is that about 80 percent of light-duty vehicles will have access to a home charger, while the remaining vehicles will utilize publicly available charging ports.

Home chargers are assumed to include both Level 1 (standard 120V outlets), which are mostly used for PHEVs and Level 2 (240V) chargers to support PHEVs as well as full BEVs. These chargers typically require 2-10 kW per port, depending on the voltage used (Level 1 or 2) and the amperage feeding the charger. The model assumes that Level 2 (L2) chargers are the preferred method of charging for several reasons: (1) higher energy output; (2) quicker charge time; and (3) grid flexibility for utilities to charge vehicles in shorter timeframes, like designated off-peak periods. The mix of charging station types and speeds may change over time as technologies evolve.

[18] BEV200: a BEV with an electric range of 200 miles. BEV with 300-mile range (BEV300) are estimated to reach purchase-price cost parity after 2050. Further discussion about total cost of ownership and BEV achieving net lifetime costs lower than ICE by 2025 is included in the Colorado ZEV Owner Benefits section.

[19] Home charging in this context is meant to include both residential locations as well as 'home-base' locations for fleets (e.g., depot) – where the vehicle is typically parked overnight or during periods when it is not being used.

As of December 2021, there are 1,488 publicly accessible charging stations in the State of Colorado, with nearly 2,900 L2 charging ports and 574 direct current fast-charging (DCFC) ports (>50 kW).[xcv] About 45 percent of these DCFC ports are Tesla superchargers that can be used only by Tesla owners currently,[xcvi] leaving 315 DCFC ports fully available to any vehicle. DCFC ports can provide rapid charging of electric vehicles, with some able to replenish 80 percent of a vehicle's battery capacity in under an hour. Increasing the availability of DCFC locations, especially along transportation corridor routes will be necessary to support the levels of ZEV penetration analyzed.

Table 9 summarizes the estimated charging infrastructure required to support ZEVs under the different penetration scenarios.

Table 9: Projected Charging Infrastructure Required by Scenario

Metric		CO GHG Roadmap		ACC II		100 x 50	
		2030	2050	2030	2050	2030	2050
Cumulative Number of Charge Ports	Home	692,500	3,576,000	692,500	4,600,000	975,000	4,625,000
	Public L2	14,500	74,000	14,500	96,000	20,000	96,000
	Public DCFC	2,000	10,500	2,000	13,500	2,500	13,500
Cumulative Investment, 2020$ (million)	Home	$790	$5,500	$790	$7,000	$1,100	$7,500
	Public	$270	$1,700	$270	$2,200	$380	$2,400

Key charging infrastructure findings from the modeling exercise are:

- By 2050, light-duty vehicle owners under the CO GHG Roadmap scenario will need to install over 3.5 million home charging ports, while the ACC II and 100 X 50 scenarios project the need for over 4.6 million home-based chargers.
- For the CO GHG Roadmap scenario's assumed levels of ZEV penetration, a total of 74,000 public L2 chargers, and 10,500 DCFC would need to be installed by 2050 for public charging needs. These numbers increase to 96,000 public L2 chargers and 13,500 DCFC under the ACC II scenario in 2050. The 100 X 50 scenario, which projects 100 percent of in-use vehicles being ZEV in 2050, requires the highest levels of charging infrastructure with 96,000 public L2 chargers and 13,500 DCFC (150 kW) by 2050.
- Under the CO GHG Roadmap scenario, light-duty home charger investments would need to increase to an average of $220 million per year (2020$) between 2025 and 2050 to purchase and install home-based charging infrastructure. Utility, government, and private investors will need to invest an average of $68 million per year over the same time period to build out a publicly accessible charging network across the state to serve the ZEV fleet.
- For the ACC II scenario, light-duty home charger investments would need to increase even further, to an average of $280 million per year (2020$), while public, utility, and private investors will need to invest an average of $88 million per year over the same time period to build out a public charging network across the state.

- Under the 100 X 50 scenario, light-duty home charger investments would need to reach an average of nearly $300 million per year from 2025 to 2050 and public, utility, and private investments in the public charging network will need to rise to an average of almost $96 million per year.

7.3 Electricity Requirements and Grid Impacts

Statewide residential and commercial electricity use in Colorado is currently 40 million MWh per year (2020). Each scenario is estimated to have its own requirements for electricity consumption and therefore will have different impacts on the grid that will require investments – ZEV charging needs by scenario are estimated to be:

- CO GHG Roadmap: 3.9 million MWh in 2030 and 21.6 million MWh in 2050, an increase of approximately 9 and 41 percent over baseline, respectively.
- ACC II: 3.9 million MWh in 2030 and 27.9 million MWh in 2050, an increase of approximately 9 and 52 percent over baseline, respectively.
- 100 x 50: 5.5 million MWh in 2030 and 28 million MWh in 2050, an increase of approximately 12 and 53 percent over baseline, respectively.

Figure 7 illustrates the projected baseline electricity use without ZEVs and the estimated incremental electricity use for ZEV charging by year and scenario.

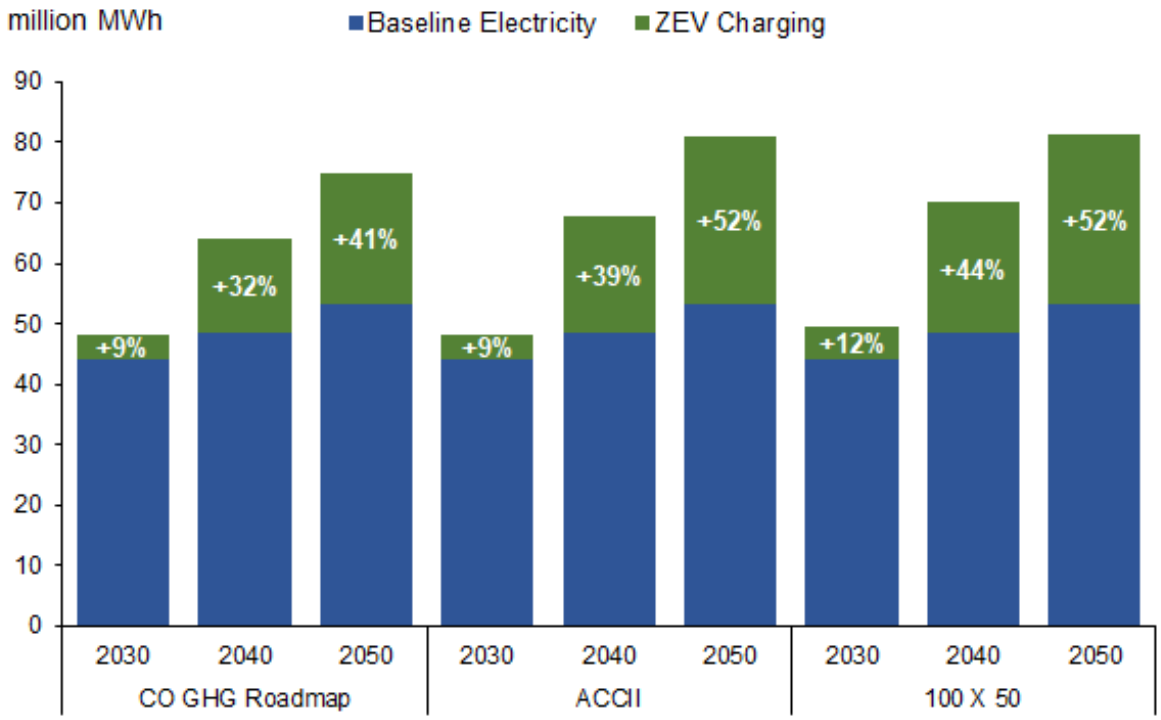


Figure 7: Estimated Total Electricity Use by Year by Scenario

7.4 Benefits to Coloradans

The analysis and modeling framework considers three broad categories of benefits to Coloradans, all of which can be combined to assess the net societal impact of LD electrification. Each is briefly discussed below, and additional detail is provided in Appendix D.

7.4.1 Utility Customer Benefits

These result from Colorado's electric utilities supplying electricity to charge ZEVs and components of (a) generation and transmission; (b) incremental generation and infrastructure capacity; (c) customer savings; and (d) utility revenue.

In general, utility costs, including distribution infrastructure, are passed on to utility customers in accordance with rules established by the Colorado Public Utilities Commission (PUC), via periodic increases in residential and commercial electric rates. However, under the PUC rules, additional electricity sales generally offset the allowable costs that can be passed on via higher rates. As such, the majority of projected utility net revenue from increased electricity sales for ZEV charging would be expected to be passed on to utility customers in Colorado, not retained by the utility companies.

7.4.2 Colorado ZEV Owner Benefits

Current light-duty ZEVs are more expensive to purchase than similar sized gasoline vehicles, but current incentive programs assist in reducing or eliminating the cost differential.[20] However, that does not reflect the total cost of ownership (TCO) that accounts for initial purchase price and projected savings from reduced maintenance and fuel cost differentials. Although purchase price cost parity is not expected until after 2030, the total cost of ownership of an EV is projected to be lower than an ICE vehicle by 2025, as shown in Figure 8, when the lifetime of the vehicle is considered.[21]

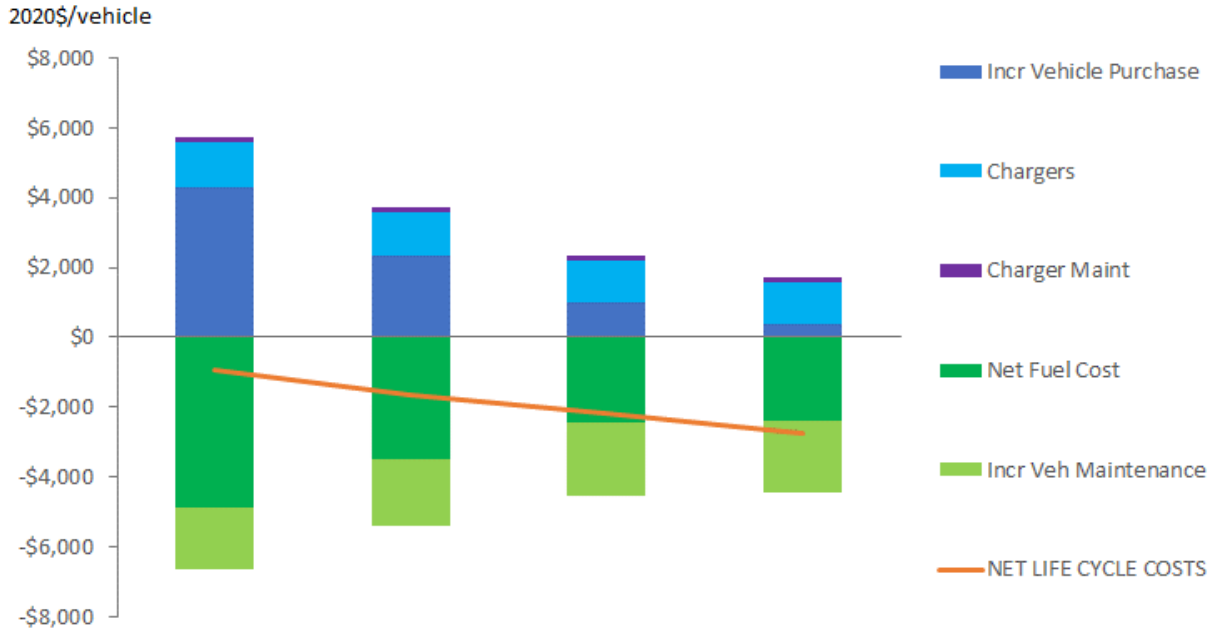


Figure 8: Projected Net Lifecycle Costs per LD ZEV (2020$)

[20] The ZEV owner benefits analysis did not include incentive program assistance.

[21] Figure 8 columns represent calendar years 2025, 2030, 2040, and 2050 (from left to right).

7.4.3 Environmental Benefits

Environmental benefits are further segregated into those that target GHG reductions (including via reduction in fuel consumption) and criteria air pollutants including nitrogen oxides (NOx) and particulate matter (PM).

7.4.3.1 Fuel and Climate

The estimated cumulative fuel savings (barrels of petroleum fuel) from ZEV use in Colorado range from a 13 percent savings (2030, ACC II scenario) to 100 percent (2050, 100 x 50 scenario). The correlated reduction in wells-to-wheel, or lifecycle, GHG emission reductions changes over time for each modeled scenario with the 100 x 50 scenario demonstrating the greatest reduction of 90 percent in 2050.

7.4.3.2 Criteria Pollutant

Similar to GHG reductions, NOx and PM emissions are projected to decrease significantly by 2050 – 95 and 67 percent, respectively. These reduced emissions could reduce negative health effects on Colorado residents including premature mortality, fewer hospital admissions and emergency room visits for asthma and reduce cases of other respiratory ailments.

7.4.4 Total Societal Benefits

The total annual estimated benefits from increased ZEV use in Colorado include cost savings to utility customers from reduced electric bills, Colorado ZEV owners' savings, climate benefits from reduced fossil fuel usage as well as monetized air quality benefits. Of particular note for 2030, as shown in Figure 9, the ZEV owner savings are estimated to be negative (i.e., a net cost generally attributable to EVs not having achieved cost parity yet).

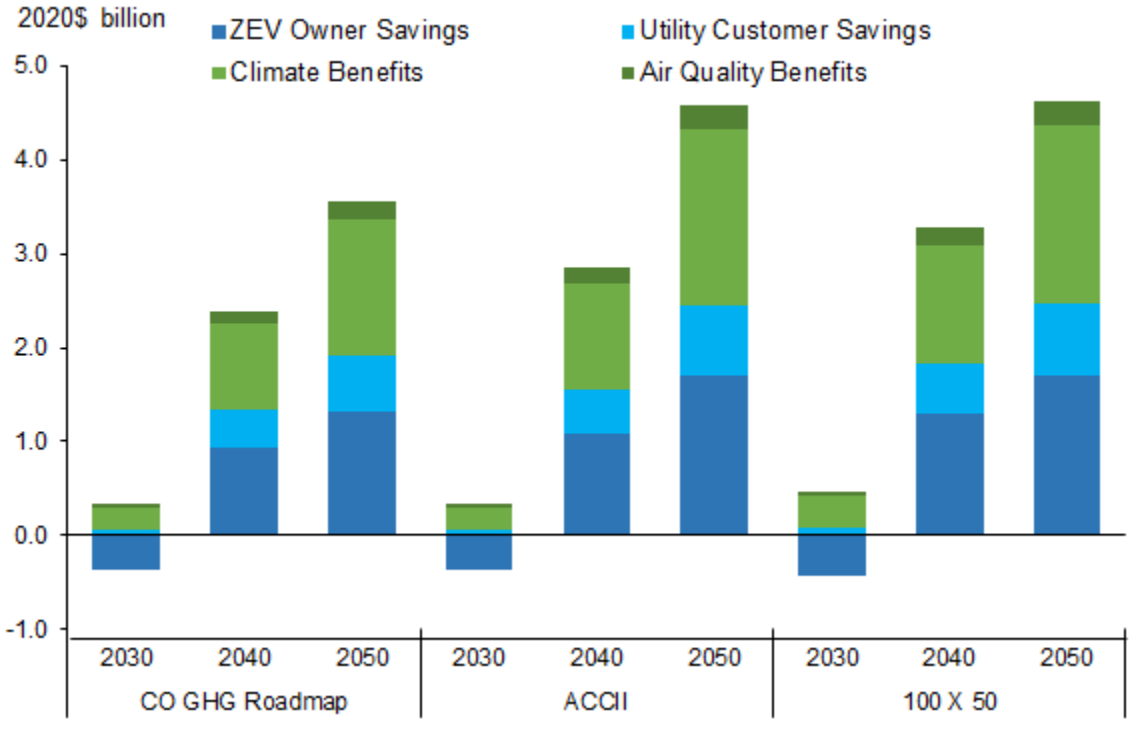


Figure 9: Projected Total Societal Benefits by Scenario

7.5 Public Investment Need Estimates

Each scenario presents different short- medium- and long-term targets for EV deployment and the discussion above identifies key areas where investments are necessary. Investments will be needed to encourage EV purchases (e.g., scrappage and/or rebate/tax incentive programs), increase access to infrastructure, and invest in the electricity grid.

With the signing of SB21-260 in June 2021, Colorado has established sustainable enterprise funds of which the Community Access, Clean Fleet, and Nonattainment Area Air Pollution Mitigation enterprise funds can in part be used to support the 100% LD transition. Combined, these three enterprise funds will have more than $730 million to be used to incentivize ZEV infrastructure and vehicle deployments over the next 10 years. In addition to these enterprises, the State will have access to federal funding through Bipartisan Infrastructure Law (e.g., National Electric Vehicle Infrastructure (NEVI) Formula Program, and other charging & infrastructure grants) and other internal funding sources such as the EV Fund while also leveraging funding from partners such as utilities, local governments, and the private sector. Given the needed investment, the State will need to explore other strategies, including extending tax credits, the role of financing from the private sector and the Colorado Clean Energy Fund.

Initial estimates of infrastructure investments (home and public) and vehicle scrappage, and incentive programs is $3.5 billion by 2030 and $12.0 billion by 2050.[22] As the State develops and expands programming related to different potential incentives, the State will determine the proper State incentives and how to appropriately leverage other resources.

Action must continue in developing strategies that most effectively make use of the enterprise funds and to ensure that roll-out of these strategies accounts for community and individual equity. Additional action is necessary to develop appropriate revenue mechanisms that can assist in bridging the gap between the available funding (state enterprise fund, federal incentives, etc.) and need.

[22] See Appendix D for how this value was estimated. Made up of three components: (1) replacement/scrappage program ($1.64 billion); (2) incentives ($0.467 billion); and (3) infrastructure ($9.893 billion) – 2050 example.

8. ROADMAP TO 100 PERCENT LD ELECTRIFICATION BY 2050

Since the State legislature passed the Climate Action Plan to Reduce Greenhouse Gas Pollution in 2019, the State of Colorado has implemented a number of actions to meet its target of reducing statewide GHG pollution 90 percent below 2005 levels by 2050. In January 2021, the Polis Administration released a comprehensive GHG Roadmap that highlights near-term actions and assesses the potential for additional policies to make progress towards the State's 2030 and 2050 goals.[xcvii] The GHG Roadmap specifically calls for a 41 percent reduction in GHG emissions by 2030 from the transportation sector which makes up the largest amount of emissions by sector within the state. By 2050, the GHG Roadmap acknowledges the need for near 100 percent deployment of LD EVs to meet the overall reduction goals.

To put the State on a path to achieving these transportation goals, in 2020 the State released its Colorado Electric Vehicle Plan which set a vision for the large-scale transition of Colorado's transportation system to zero emission vehicles. That plan called for the development of a roadmap to full electrification of the light-duty vehicle fleet. This Roadmap identifies and analyzes policies, programs, incentives, and actions that the State could adopt or undertake and their various implications, cost/benefits, and timeframes that will allow the State to reach its 2020 Electric Vehicle Plan target of 100 percent light-duty vehicle electrification by 2050.

This Roadmap is being released at a time in which both the State of Colorado and Congress have passed significant pieces of legislation (Colorado's SB 21-260 in June 2021 and Congress's IIJA in November 2021). Both Acts have the potential to make significant improvements to the state's transportation system by funding policies and programs that reduce emissions and support the transition to zero-emission vehicles. This Roadmap aims to identify and prioritize actions that can take advantage of these new funding streams in a way that will support the State's emission reduction goals.

8.1 Stakeholder Engagement

In the summer and fall of 2021, five stakeholder engagement virtual sessions were held that played an instrumental role in informing the development of the Roadmap.[23] Several of the near- medium, and long-term actions outlined below were either informed by or directly recommended by stakeholders. Several overarching takeaways that informed this Roadmap are highlighted below.

8.1.1 Addressing EV Costs

Addressing the high up-front cost of electric vehicles continues to be a significant barrier to increasing electric vehicle deployment. To address this barrier the following ideas were identified by stakeholders: 1) increase incentives for electric vehicle adoption, especially those tailored to low-income communities and to used vehicles; 2) provide education on existing incentives.

8.1.2 Addressing Equity and a Just Transition

Stakeholders acknowledged that while transportation electrification is important to achieving State decarbonization goals, other initiatives that reduce/remove VMT all together and support multimodal systems (especially for communities that are disproportionately burdened/own fewer vehicles) will also be critical. Stakeholders also identified the following key recommendations surrounding addressing equity and a just transition.

[23] ERM held five focused stakeholder engagement sessions in 2021: August 26th Kick-off and Ensuring Equitable Engagement; September 28th Public Webinar; October 7th Vehicle Infrastructure Development; October 18th Electric Vehicle Market Development; October 28th Draft Roadmap Review

- Effectively communicate stakeholder engagement and policy development to all communities by providing additional services (e.g., increased engagement opportunities, language services).
- Develop a used EV market to reach disadvantaged and low- to moderate-income populations in urban and rural communities by educating communities on used EV offerings and incentivizing used EV purchasing through a qualified income incentive.
- Developing a just transition for existing oil and gas supply chain workers and creating workforce development opportunities for the EV supply chain will be key pieces to the light-duty transition to ZEVs.

8.1.3 Sector Specific Engagement

Sector specific engagement was discussed throughout the stakeholder engagement process. Stakeholders noted that, in the short term, there should be targeted programs to electrify vehicles that will have the greatest impact in reducing emissions (e.g., TNC and fleet vehicles). Identifying financing and program opportunities that address different market segments should also be a priority.

8.1.4 Program/Policy Development

A number of stakeholders noted that the State should develop a cohesive set of policies and programs that are complementary to each other and not duplicative.

8.1.5 Education and Communication

Stakeholders highlighted the importance of education and outreach on charging infrastructure availability especially in underserved communities. Others noted the general population's knowledge around electric vehicles is dated and highlighted that more engagement and coordination with existing neighborhood organizations, agencies, and groups would enable a greater understanding of electric vehicles. Several stakeholders highlighted that rural development, and dealership engagement and communication will be important to increasing electric vehicle adoption.

8.1.6 Infrastructure Development

A number of stakeholders highlighted the importance of developing charging infrastructure that considers different market segments or different community needs. Not all areas will benefit from the same amount of or type of EV charging infrastructure. Others also noted that metrics should be developed to evaluate how charging infrastructure should be built out and that improving and streamlining the siting and permitting process will be essential to meeting State targets.

8.2 Actions to Increase Ease of Adoption

8.2.1 Near-Term Actions (1-3 years)

- Evaluate and implement programs that increase support for municipal fleet electrification by working with municipal governments to develop programs that will lead to more rapid fleet electrification (e.g., bulk buy electric vehicle programs, vehicle scrappage programs, among others).
- Adopt a program modeled on the California Advanced Clean Cars II program.[24]

[24] The CA Advanced Clean Cars II (ACC II) rule is currently under consideration in CA and has not been finalized. Modeling a rule on the ACC II can achieve significant electrification of the light-duty fleet by 2050.

- Work with local governments to develop a transparent scoring rubric to support charger siting by utilizing a set of criteria (e.g., traffic density, distance to existing DCFC, and equity measures) and commit to EVSE program timelines and allow for public input and program flexibility. Ensuring that there is clear communication at the beginning of a program will allow key stakeholders to know what expectations have been set so that they can better plan for the permitting process. The State should also partner with local governments to expedite the EVSE permitting process by creating a standardized permit review form that streamlines make-ready infrastructure development and removes unnecessary permitting requirements (e.g., pre-approvals) that municipalities could adopt.
- Working with utilities to streamline their internal and external planning processes to limit charging development delays from grid connections. The State can play a meaningful role in working with utilities to make easement and capacity maps readily available to providers and can work with the State's regulatory and oversight bodies to ensure that utilities are able to dedicate State and other resources deploying effective charging infrastructure programming.
- Establish new State fleet procurement targets for electric vehicles that extend beyond 2025 and evaluate the potential for an EV fleet rule codifying requirements for large light-duty fleets.
- Partner with municipalities and other large fleet owners (e.g., vehicle rental companies, vehicle leasing companies, among others) throughout the state to collaborate on ways to increase the market for used EVs. These discussions should consider the role that public and private fleet owners and dealerships can have in creating a used EV marketplace where consumers can compare and learn more about EV.
- State entities, in partnership with other key stakeholders like utilities, should collaborate with private fleet owners to incentivize and provide technical assistance to help fleets develop and implement vehicle electrification targets.
- Provide incentives for used EVs to encourage growth and to increase the cost competitiveness of EVs with used ICE vehicles (e.g., California Clean Vehicle Assistance Program).[xcviii]

8.2.2 Medium-Term Actions (4-7 years)

- Work with TNC companies to set targets to increase the percentage of TNC mileage that is provided by EVs after 2030.
- Increase and incentivize public and private fleet turnover of EVs in the near term to increase the number of vehicles within the secondary vehicle market in the future.
- Subsidize electric car shares paired with electric micromobility specifically for disproportionately impacted communities and high emission areas.

8.2.3 Long-Term Actions (8 + years)

- Evaluate ways to work with municipalities and building owners to finance EV building retrofit programs for existing buildings.
- Support municipalities that are tackling efforts to increase EVSE deployment during site development.
- Continue to support the Energy Code Adoption Toolkit and Code Helpline to assist municipalities in adopting updated building codes.

8.3 Actions to Increase Affordability

8.3.1 Near-Term Actions (1-3 years)

- Colorado should consider expanding action taken through HB 19-1159 to extend the tax credit availability beyond 2026 through at least 2030.
- Many Coloradans do not purchase a new vehicle and instead rely on the used vehicle market. The State should investigate how used vehicles can be included in the EV incentive – something that is expressly forbidden under the current income program.
- The State should implement a vehicle replacement program designed to encourage more rapid ICE vehicle replacement with EVs.
- Introduce flexibility for utilities to finance vehicles and infrastructure.
- The State should continue to work directly with dealerships across the state, in addition to and in partnership with utility programming, to ensure that dealerships have the training and educational tools they need to educate consumers on differing EV models. This can take the form of educational programs or financial incentives.

8.3.2 Medium-Term Actions (4-7 years)

- Evaluate the role of State leadership in developing tiered leasing models based on income eligibility that are within reach for low wage earners.
- Provide incentives and guidance for fair financing practices for used EVs to encourage growth and to increase the cost competitiveness of EVs with used ICE vehicles (e.g., California Clean Vehicle Assistance Program).[xcix]

8.3.3 Long-Term Actions (8 + years)

- Continue to evaluate affordability of transportation electrification, especially for disproportionately burdened and lower income communities and develop policies and programs that support increased affordability.

8.4 Actions to Increase Awareness

8.4.1 Near-Term Actions (1-3 years)

- Work with utilities and other stakeholders to: 1) establish long term infrastructure build-out plans, 2) pair fleet advisory services with infrastructure development.
- Work with utilities to implement effective charging infrastructure rates that incentivize managed charging.
- Develop equitable EV programming to take into consideration the impact on low-income customers by developing community-based and multi-family charging infrastructure, car share programs, and by creating electrified multimodal transportation. Subsidize electric car shares paired with electric micromobility specifically for disproportionately impacted communities and high emission areas.
- Encourage and facilitate utility collaboration across the state to enable streamlined and planned infrastructure development across investor-, municipally- and cooperatively-owned utility service territories.

8.4.2 Medium-Term Actions (4-7 years)

- Increase public awareness. Design and implement a comprehensive and cohesive marketing program that can combat EV adoption barriers such as range anxiety by highlighting the publicly accessible charging network around the state.
- Develop marketing and outreach plans to communicate and support used EV purchases.
- Establish an EV infrastructure toolkit. The State should work with local governments and regional governments to develop an infrastructure toolkit to (1) identify charger options, (2) provide utility contacts for the installation of the supporting electrical equipment, (3) recommend qualified electricians, (4) identify rebates, and (5) detail local permitting requirements.

8.4.3 Long-Term Actions (8 + years)

- Continue to develop and expand upon existing marketing and outreach programs.

8.5 Actions to Enable a Just Transition

8.5.1 Near-Term Actions (1-3 years)

- Develop statewide workforce ZEV training program. Colorado can work with public universities and community colleges to develop workforce training and career programs for new workers and support the existing workforce with on-the-job training. In addition to developing a workforce of technicians and engineers to support ZEVs, electricians must simultaneously be trained to support the growing ecosystem of chargers. The State should ensure training programs are appropriately communicated.
- Convene key stakeholders to discuss key gas vehicle transition pain points. The State should convene stakeholders across the entire oil and gas supply chain (from oil and gas producers to convenience store owners) to evaluate and better understand the types of programs and policies that may best support their transition to a low-carbon economy (e.g., workforce training, relocation funding, etc.)

8.5.2 Medium-Term Actions (4-7 years)

- Provide funding for job training for former oil and gas workers. Many of the jobs that will be created by the clean energy transition require the expertise of the existing fossil fuel workforce. The State should provide funding opportunities for job training in clean energy and transportation electrification fields for current oil and gas workers to create a just transition for workers and to fill vital jobs in the clean energy economy.

8.5.3 Long-Term Actions (8 + years)

- Continue to work with and support oil and gas workers throughout the supply chain on enabling a just transition to a low carbon future.

APPENDIX A LITERATURE REVIEW: SUMMARY OF LOCAL, STATE AND FEDERAL PROGRAMS IN THE U.S. AND SELECT INTERNATIONAL COUNTRIES

State Pathways to 100% ZEVs

Executive Order N-79-20 (Gov. Newsom)

- 2035: 100% of in-state sales of new passenger cars and trucks will be ZEV; 100% of drayage trucks and off-road vehicles and equipment ZEVs where feasible
- 2045: 100% of M/HDV be ZEV for all operations where feasible

Status: Executive Order signed September 2020 – must be passed by state legislature

New York State S.2758/A.4302 (active)

- 2035: 100% of new passenger cars and trucks and M/HDV offered for sale or lease, or sold, or leased, for registration in the state be ZEV

Status: Passed both chambers, signed by Governor Hochul in September 2021

Washington State E2SHB 1287 (partially vetoed)

- 2030: Once a road usage charge, or equivalent fee or tax based on vehicle miles traveled, is in effect in the state of Washington with at least 75 percent of the registered passenger and light duty vehicles in the state participating, then a goal is established for the state that all publicly owned and privately owned passenger and light duty vehicles of model year 2030 or later that are sold, purchased, or registered in Washington state be electric vehicles. (Section 6)

Status: Failed – Governor Inslee partially vetoed the bill: "Section 6 of the bill ties a very important goal of electrifying our transportation sector to the implementation of a road usage charge program. Transportation is our state's greatest source of carbon emissions and we cannot afford to link an important goal like getting to 100% zero-emission vehicles to a separate policy that will take time to design and implement…setting and achieving a goal of 100% electric vehicles is too important to tie to the implementation of a separate policy like the road usage charge."

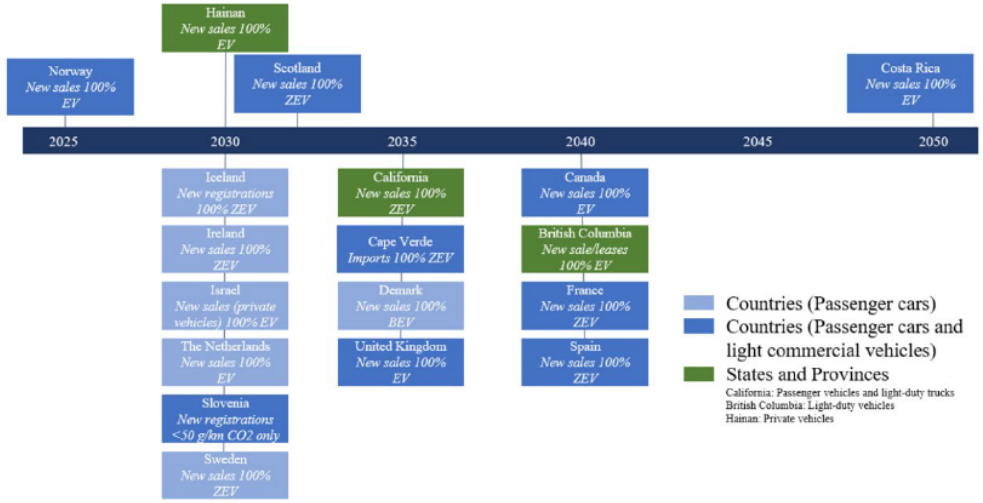
Country Pathways to 100% ZEVs: United Kingdom

Ten Point Plan (Prime Minister Johnson)

- 2030: End the sale of new petrol and diesel cars and vans by 2030 (hybrid cars and vans that can drive a "significant distance with no carbon coming out of the tailpipe" permitted)
- 2040: 100% ZEV sales (hybrids not permitted)

Status: Presented as element of strategic plan – additional legislation needed to accelerate roll out of ZEVs

For additional international aspirations, see MJB&A's EV Market Report



Country Pathways to 100% ZEVs: Norway

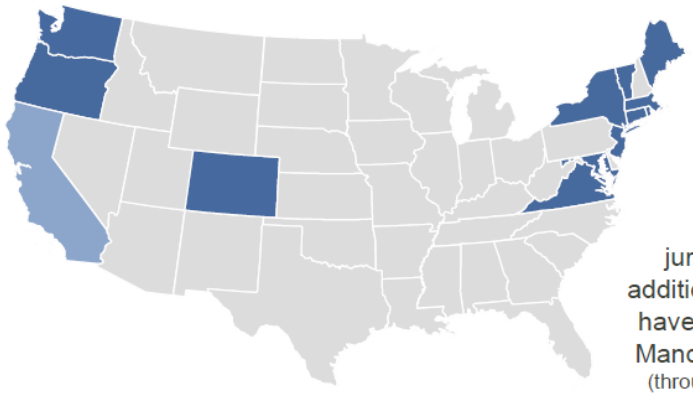
Policies

- Policies to force a transition to 100% EVs by 2025 started at the top, with federal action.
- Spurred by Norway's environmental and climate commitments.
- In simplified terms, Norway is taxing polluting activities and incentivizing clean transportation. New car purchase tax is calculated using a combination of weight, CO_2 and NOx emissions

Status: In progress, with many active incentives:

- No annual road tax
- Maximum of 50% o the total amount on ferry fares for Evs
- Parking fee for EVs implemented locally but with an upper limit of a maximum 50% of the full price
- Access to bus lanes
- Company car tax reduction reduced to 40%
- No purchase/import taxes
- Exemption from 25% VAT on purchase.

ZEV Mandate Overview



DE, PA and D.C. have adopted California's LEV standards for GHG and criteria emissions but not the ZEV mandate.

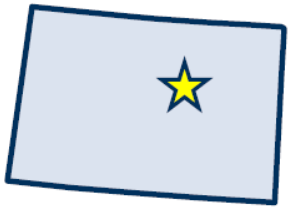
12

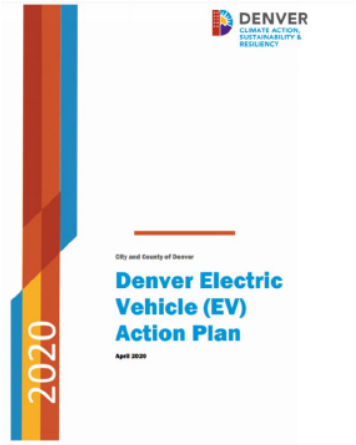
jurisdictions in addition to California have adopted ZEV Mandate standards (through Section 177)

Primary Categories of Vehicles that Can Earn Credits

- Zero Emissions Vehicles (**ZEVs**): include battery electric vehicles and fuel cell electric vehicles, with credit amount based on all electric range of vehicle (max: 4 credits)
- Transitional Zero Emissions Vehicles (**TZEVs**): includes plug-in hybrid electric vehicles with at least a 10 mile all electric range, with credit amount based on electric range (max: 1.1 credits); also include hydrogen internal combustion vehicles (max: 1.25 credits)
- Partial Zero Emissions Vehicles (**PZEVs**) / Advanced Technology PZEVs: low emissions conventional vehicles or hybrid vehicles; as of 2018 **can no longer earn credits** (though banked credits from previous years can be used at a discount through MY 2025)

Denver – Denver Electric Vehicle (EV) Action Plan (April 2019)





Goals

- 2025: 15% of Denver vehicle registrations are electric
- 2030: 30% of Denver vehicle registrations are electric
- 2050: 100% of light-duty vehicles are electric

Measure of Success

Information not available or not yet developed/implemented

Actions

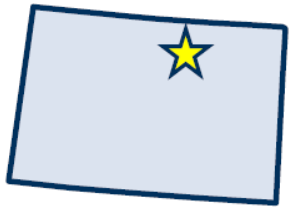
Bolster Charging Infrastructure Availability:
- Xcel Energy Transportation Electrification Plan
- Public Fast Charging Rates
- Build EV Partnerships
- Support New Public EV Chargers: city property EV chargers, park-n-ride EV chargers, higher density and rental EV charging, workplace EV charging program
- EVSE Installation Incentives

Drive Community Awareness:
- City Lead by Example: EV messaging, branding, and employee campaign
- Targeted Outreach Campaigns: fleet owner and workplace campaign, underserved communities campaign, EV resources for schools

Facilitate EV Adoption:
- Residential Retrofit Installation Guide
- EV Charger Permitting Guide
- Tiered EV Incentives

Support EV Services and Innovation
- EVs for Transportation and Mobility Services
- EV Mobility Hubs

Fort Collins – Electric Vehicle Readiness Roadmap (October 2018)



Goals

- Increase the use of EVs over conventional fuel vehicles in Fort Collins and the region.
- 2025: 100% of LDV purchases for City fleet plug-in electric; incorporating battery electric transit buses, subject to the availability of suitable technology

Measure of Success

Since releasing the plan, Fort Collins has:

- Conducted EV Group Buy programs (87 purchases coordinated in 2020)
- Is offering webinars and resources
- Added charging to seven locations for a flat charging rate of $1/hour

Actions

Short-term (1-2 years)

- Policies: clarify city policy related to EV charging; allow right-of-way locations for EV charging station installations; establish and enforce EV parking rules
- Incentives: support public charging station installation; recognize local businesses with workplace charging
- Leading by example: pursue electrification opportunities within the city's LDV and transit fleet

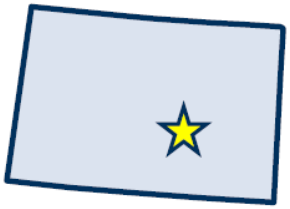
Medium-term (3-5 years)

- Policies: revise building codes to require EV-ready developments
- Incentives: incentivize consumer EV purchases
- Utilities: support smart grid operations for EVs; increase renewable electricity for EV charging; access and adjust utility rate structures
- Leading by example: install EV charging for the city fleet; encourage EV adoption by city employees

Long-term (within 10 years)

- City planning & regional coordination: encourage EV ride-hailing and car sharing
- Utilities: upgrade electricity distribution infrastructure
- Emerging technologies: pursue living laboratory projects

Colorado Springs – Electric Vehicle Readiness Plan



Electric Vehicle Readiness Plan

Goals

Goal 4 of the City's 2019 Comprehensive Plan: to improve preservation, resource conservation, air quality, and protection of our viewsheds

Measure of Success

Under development

Actions (to be considered)

- A roadmap for conversion of City and Utilities fleet to electric vehicles
- Public education and EV adoption incentives
- Policy adoption, including rate structure, infrastructure ownership, and land use and building code recommendations to support EVs
- Identification of ideal EV charging station locations, including needed utility infrastructure upgrades

Los Angeles – L.A.'s Green New Deal: Sustainable City pLAn 2019 (April 2019)

Goals

- 2025: 25% ZEVs (baseline: 1.4% of vehicles as of September 2018)
- 2028: 100% ZEVs for City fleet vehicles
- 2035: 80% ZEVs
- 2050: 100% ZEVs

Measure of Success

pLAn 2019 with the goals listed above has not yet released status reports. pLAn 2015's 3rd Annual Report: For nearly two years, convened an EV Task Force (TF) with 13 city departments on a monthly basis to coordinate all City fleets – General Services, LAPD, LAFD, LAWA, POLA, DWP. The TF helped the City procure >475 EVs and developed an EV charger deployment strategy for municipal facilities and in the public right of way.

Actions (to be considered)

- Distribute 1,000 used EV rebates, 11,500 Level 2 EV charger rebates, and 75 DC fast charger rebates (including initiating a design competition for the gas station of the future)
- Develop a zero emission roadmap for LAX (including releasing an RFQ)
- Develop roadmap for Fossil Fuel Free Zone by 2021; and implement by 2030 (including using incentives to eliminate foot truck idling)
- Install 10,000 publicly available EV chargers by 2022; and 28,000 by 2028 (including updating building code to expand EV charging requirements to meet anticipated need)
- Electrify 10% of taxi fleet by 2022; and 100% by 2028 (including launching an incentive)
- *Other elements beyond LDV include bus electrification and M/HD trucks and vehicles*

Minnesota – Accelerating Electric Vehicle Adoption: A Vision for Minnesota (2019)

Goals

- 2030: powering 20% of the LD cars in the state with electricity: half expected to be PHEV and half BEV

Measure of Success

- Currently seeking public input to update plan – specifically to consider EV delivery trucks, semis, and buses; charging; passenger cars and trucks
- Registrations:
  - 2018: nearly 7,000 *(no breakdown)*
  - 2021:18,749 (11,184 BEV, 7,565 PHEV)
- Charging infrastructure:
  - 2018: 600 *(no breakdown)*
  - 2021: 1,144 (953 L2, 191 DCFC)

(2021 data provided by the Minnesota EV Dashboard)

Actions

Accelerate sales and use

- Incentives
- Education
- Bulk buy discounts
- Electric buses

Build out charging infrastructure

- Workplace charging
- Fast charger stations

Coordinate on regional and national initiatives

- Consistency in regions and states

Prioritize renewable energy to charge EVs

- Install fast charging stations along interstates and highways statewide by 2030

Florida – Electric Vehicle Roadmap (2020)

Goals

- Identify EV charging infrastructure impacts on the electric grid
- Identify solutions for any negative impacts
- Locate areas that lack EV charging infrastructure
- Identify best practices for siting EV charging stations
- Identify technical or regulatory barriers to expansion of EV charging infrastructure

Measure of Success

Plan released in Dec 2020 so not much to evaluate – historical data provided in the report shows the LDV EV population grew by an avg. of 1,600 vehicles per month in 2019, 32% higher than 2018, and >4x the monthly adoption rate of 2017

Recommendations

- Planning (e.g., DMV develop and publish quarterly standardized reporting)
- Installation permitting (e.g., Building Commission develop standardized process for reviewing/permitting)
- Varying needs (e.g., TNCs, taxis, and shuttles; disadvantaged communities; rural communities)
- Financing and incentives (e.g., develop state incentives to support workplace charging)
- Education (e.g., funding for statewide information campaign)
- EV adoption and forecasting infrastructure needs (e.g., state agencies develop methodologies to track/forecast EV sales and infrastructure requirements)
- Infrastructure interoperability, performance, and monitoring (e.g., state agencies develop relevant standards)

Hainan, China – Clean Energy Vehicle Development Plan (2019)

Sector	Subsector	Targets							
		2019		2020		2025		2030	
		New	Stock	New	Stock	New	Stock	New	Stock
Government		100%		100%		100%	100%	100%	100%
Bus		100%		100%	80%		100%		100%
Taxi	Conventional	100%			100%		100%		100%
	Ride-hauling	80%		100%		100%	90%		100%
Urban freight	Postal, logistics	100%		100%		100%	60%	100%	100%
Sanitation		50%		50%		50%	60%		100%
Rental	Car-sharing	100%		100%		100%	80%	100%	100%
	Conventional	20%		40%		100%	60%		100%
Tour coach				20%		100%	50%		100%
Inter-city coach				20%		100%	45%		100%
Private		10%		40%		80%		100%	

Electric Vehicles Clean Energy Vehicles

Goals

- 2030: Fleet is fossil fuel-free and fully transitioned to "new energy vehicles" (includes BEVs, PHEVs, and FCEVs) (*see chart*)
- Charger targets: overall charger-to-EV ratio is required to meet 3-to-1 by 2020, and 2-to-1 by 2025 (baseline 4.5-to-1)

Measure of Success

- As of the release date, Hainan had deployed 37,000 clean energy vehicles (CEVs) (2.9% of total registrations) thanks to the decade-long new energy vehicle demonstration pilot program and associated incentives introduced in major cities in the region. Unclear progress since release.

Actions

- Prioritize CEV deployment in tiered manner by zone (Zone 1 [includes capital city], □ Zone 2 [coastal cities and cities] □ Zone 3 [inland cities and towns])

Electric Vehicles

- Production policies (e.g., tariff incentive for CEVs)
- Fiscal incentives (e.g., subsidies, loan reductions)
- Non-fiscal incentives (e.g., road access privilege, zero carbon emissions zones)
- Charging infrastructure (e.g., streamline permitting process)
- Hydrogen refueling infrastructure (e.g., development plan, station availability)

Natural Gas Vehicles

- Fiscal incentives (e.g., subsidies, exemption from vehicle purchase tax)
- Refueling infrastructure (e.g., development plan, station availability)

Netherlands – Mission Zero (2019)

Mission Zero
Powered by Holland

Goals

- 2030: 100% new passenger vehicles sold are ZEV, whether hydrogen-electric or battery-electric; foresee a charging requirement of 1.8 million public, semi-public and private charge points

Measure of Success

- Electric passenger vehicles
  - 2018: 142,736
  - 2021: 173,236
- Charging ports
  - 2018: 37,707
  - 2021: 68,170

Recommendations

Knowledge sharing

- Cooperation – Formula E-Team; Netherlands Knowledge Platform for Charging Infrastructure; executed Green Deals and administration agreements (e.g., Car Sharing Green Deal); E-mobility Innovation/Acceleration Programme
- Knowledge development – ElaanLN (partnership of charging network operators); Living Lab Smart Charging platform; Dutch-INCERT consortium Innovation Center
- Connect action across provinces/municipalities

Faster and smarter charging

- Fast charging infrastructure
- Open standards
- Smart charging
- Research

Vehicles

- Made in Holland – establishing partnerships
- Various sectors: car sharing, taxis, private vehicles
- Local and national incentives

Santa Monica, California – Zero Emissions Delivery Zone Pilot

Goals

- Provide a blueprint for cities to adopt zero emissions delivery zones and provide best practices for other zero emissions zones.
- Provide ahead of the curve learnings to delivery companies for zero emission delivery zone operations by working hand in hand with the project implementation team.
- Immediate benefits to the local community such as reduced air pollution, GHG emissions, noise and congestion, as well as improved safety.
- Provide economic opportunity to small businesses and individuals through access to zone benefits.

Measure of Success

N/A – not yet implemented

Actions

One-square mile area in the commercial activity core of Santa Monica that will deploy:

- Micromobility for food and parcel delivery
- Heavy-duty, medium-duty and light-duty electric delivery vehicles
- Commercial electric vehicle car sharing
- Priority zero emission loading zones and curb management
- Mobile charging applications for delivery

Others considering or already implementing: Madrid, London, Munich and over 250 other cities primarily located in Europe

New York City – Congestion Surcharge

Goals

- Reduce congestion and influence driving patterns
- Improve air quality
- Create revenue

Measure of Success

N/A – not yet implemented

- Missed planned January 2021 start
- Received letter from FWHA saying that an Environmental Assessment would be the "appropriate next step"

Potential benefits:

- 58,000-59,000 fewer auto trips (varies by which charging scenario is chosen)
- ~7% reduction in GHG emissions
- $810M-$1.1B in annual net revenues

Actions

- Set price – past proposals recommended charging $12-$14 for cars and $25 for trucks with prices fluctuating based on time of day (drivers only tolled once per day)
- Set geographic zone – original bill proposed all of Manhattan below 60th street with a few exceptions
- Set taxable entities – carve-outs included for emergency vehicles or drivers with disabilities and credits for income-qualified or geographically-qualified residents
- Allocate funding – original bill proposed that 80% would go to capital projects on subways and buses and 20% to Metro-North and the Long Island Rail Road
- Implement phased approach –

1. Focuses on investing in transit connections between the Central Business District and outer boroughs/ suburbs.
2. Surcharge on taxis and for-hire vehicle trips within the District. Beginning in February 2019, New York began charging $2.50 for taxis, $2.75 for private ride-hailing vehicles for single users, and $0.75 per customer for shared ride-hailing rides.
3. Finalize the congestion pricing zone and charge private autos traveling in Manhattan's Central Business District below 60th street. *(under consideration currently)*

Others considering or already implementing: San Francisco, Los Angeles, Singapore, London, Stockholm (overview of three)

Spain – Madrid Central City Center Low Emission Zone / Barcelona's Superblock/Low Emissions Zone

Goals - Madrid

- Improve air quality and promote friendlier city center for pedestrians, cyclists, neighbors, and visitors

Measure of Success

- Implemented Nov. 2018
- Spain's Supreme Court struck down the ban in May 2021 citing procedural errors

Actions

- Only BEVs, FCEVs, PHEVs with a minimum electric range of 40 km, and range-extended electric vehicles (REEVs) are allowed to circulate and park without restrictions in the LEZ. All other vehicles face limits on access duration and parking. Gasoline cars up to Euro 2 and diesel cars up to Euro 3 are prohibited.

Goals – Barcelona

- 2030: Convert entire central grid into a greener, pedestrian-friendly area almost totally cleared of cars (21 street conversion)

Measure of Success

- First introduced in 2016; new conversion plan beginning 2022
- According to a 2019 study, a full realization of the city's 503-block plan could prevent 667 premature deaths per year (due to heat related illnesses/other benefits)

Actions

- Convert 21 streets into a kind of super-superblock, freeing up space for 21 new pedestrian plazas at what were previously intersections
- Vehicle traffic will only be permitted around the perimeter, leaving streets within the district only accessible by motor vehicle to residents, essential services or deliveries.
- In conjunction with a LEZ that convers 95 square km which launched January 2020 – vehicles without a DGT environmental label cannot circulate in the LEZ

Others considering or already implementing: Madrid, London, Munich and over 250 other cities primarily located in Europe

APPENDIX B PRIOR STUDIES: SUMMARY OF STATE EV DATA

SUMMARY OF ZEV PENETRATION INFLUENCES AND FINDINGS FROM PRIOR STUDIES

- Near term: now until 2025
  - CEO 2020 EV Plan[c]
    - More than doubled the number of EVs registered in Colorado from 11,238 in August 2017 to over 24,000 in June 2019. (pg. 4)
    - As of December 2019, Colorado had over 25,000 registered plug-in EVs and was fifth in the country for market share of BEV. (pg. 15)
    - State agencies will prioritize purchase of ZEVs for light-duty applications, increasing the number of ZEVs in operation or on order from at least 200 by end of 2020 to 375 by January 2022, with a goal of electrifying all vehicles that have appropriate use cases by 2030. (pg. 19)
    - Annual sales targets from 4,156 in 2017 to 10,500 by June 30, 2020, and 23,500 by June 30, 2022. (pg. 19)
  - MJB&A Electric Vehicle Cost-Benefit Analysis (2019)[ci]
    - Baseline scenario: The Baseline scenario assumes that post-2025 sales growth continues at the same annual increase as the ZEV standard would require for MY 2023-2025. PEV penetration is assumed to be 1 percent in 2025. In the Baseline scenario, the number of PEVs registered in Xcel's service area would increase from approximately 11,600 today to 35,400 by 2025.
    - Colorado EV Plan scenario: The level of PEV penetration required to achieve Colorado's EV Plan goal of 940,000 EVs by 2030 and includes a modest increase in rate of growth for post-2030 EV sales. PEV penetration is assumed to be 10 percent in 2025. // For the Colorado EV Plan scenario, the number of PEVs registered in Xcel's service area would increase to 308,400 by 2025.
    - High EV Growth scenario: The level of PEV penetration required to achieve an economy wide GHG emission reductions of 80 percent from 2005 levels by 2050. The High EV Growth scenario aims to encompass a path that would help meet [an aggressive goal of limiting 1.5°C warming]. PEV penetration is assumed to be 16 percent in 2025.
- Mid-term: post EV Plan 2025-2030
  - CEO: 940,000 EVs by 2030 – requires 50+ percent growth by year (pg. 4)[cii]
  - ICCT: 70 percent EV sales by 2030; 940,000 EV stock by 2030 (pg. 2)[ciii]
  - MJB&A 2017 Cost-Benefit Analysis (pg. 2)[civ]
    - Moderate PEV Scenario – 6 percent of in-use LDV by 2025 and linear PEV penetration through 2050.
    - High PEV Scenario – LDV PEV penetrations of 26 percent by 2030, 60 percent by 2040 and 98 percent by 2050.
  - CO DPHE: 298,045 light-duty vehicle sales with 18,099 ZEV split between BEV and PHEV at 75 percent and 25 percent, respectively (pg. 5)[cv]
  - MJB&A Electric Vehicle Cost-Benefit Analysis (2019)[cvi]
    - Baseline scenario: The Baseline scenario assumes that post-2025 sales growth continues at the same annual increase as the ZEV standard would require for MY 2023-2025. PEV

penetration is assumed to be 2 percent in 2030 and 8 percent in 2040. // In the Baseline scenario, the number of PEVs registered in Xcel's service area would increase from approximately 11,600 today to 35,400 by 2025. Assuming the same annual increase in percent PEV penetration in later years, there would be 77,800 PEVs in 2030 and 343,000 in 2040.

- Colorado EV Plan scenario: The level of PEV penetration required to achieve Colorado's EV Plan goal of 940,000 EVs by 2030 and includes a modest increase in rate of growth for post-2030 EV sales. PEV penetration is assumed to be 15 percent in 2030 and 29 percent in 2040. // For the Colorado EV Plan scenario, the number of PEVs registered in Xcel's service area would increase to 545,000 in 2030. Assuming a modest annual increase in percent PEV penetration after 2030, there would be 1.2 million PEVs in the territory in 2040.
- High EV Growth scenario: The level of PEV penetration required to achieve an economy wide GHG emission reductions of 80 percent from 2005 levels by 2050. The High EV Growth scenario aims to encompass a path that would help meet [an aggressive goal of limiting 1.5°C warming]. PEV penetration is assumed to be 26 percent in 2030 and 60 percent in 2040. // To put the State on a path to achieve an 80 percent reduction in economy-wide emissions from 2005 levels by 2050 (High EV Growth scenario) there would need to be approximately 920,000 PEVs in Xcel's service area by 2030, rising to 2.4 million in 2040.

- Long-term: 100 percent transportation electrification - Post 2030
  - CEO: As part of the development of the GHG Pollution Reduction Roadmap, the State will evaluate the necessary timeline for light-duty electrification to achieve the target of 90 percent emissions reductions by 2050. (pg. 20)[cvii]
  - MJB&A Electric Vehicle Cost-Benefit Analysis (2019)[cviii]
    - Baseline scenario: The Baseline scenario assumes that post-2025 sales growth continues at the same annual increase as the ZEV standard would require for MY 2023-2025.PEV penetration is assumed to be 33 percent in 2050. // In the Baseline scenario, the number of PEVs registered in Xcel's service area would increase from approximately 11,600 today to 35,400 by 2025. Assuming the same annual increase in percent PEV penetration in later years, there would be 1.5 million in 2050.
    - Colorado EV Plan scenario: The level of PEV penetration required to achieve Colorado's EV Plan goal of 940,000 EVs by 2030and includes a modest increase in rate of growth for post-2030 EV sales. PEV penetration is assumed to be 56 percent in 2050. // For the Colorado EV Plan scenario, assuming a modest annual increase in percent PEV penetration after 2030, there would be 2.5 million in 2050.
    - High EV Growth scenario: The level of PEV penetration required to achieve an economy wide GHG emission reductions of 80 percent from 2005 levels by 2050. The High EV Growth scenario aims to encompass a path that would help meet [an aggressive goal of limiting 1.5°C warming]. PEV penetration is assumed to be 88 percent in 2050. // To put the State on a path to achieve an 80 percent reduction in economy-wide emissions from 2005 levels by 2050 (High EV Growth scenario) there would need to be approximately 4.0 million in 2050.

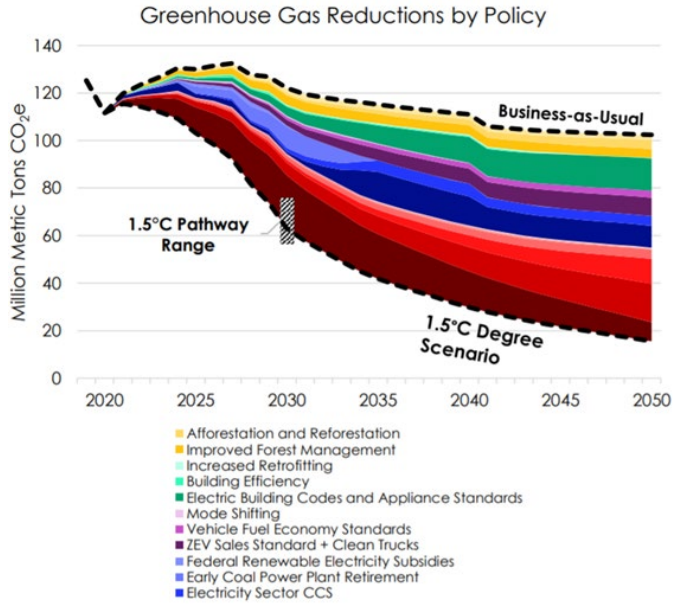
PROJECTIONS FOR GHG EMISSION REDUCTIONS FROM PRIOR STUDIES

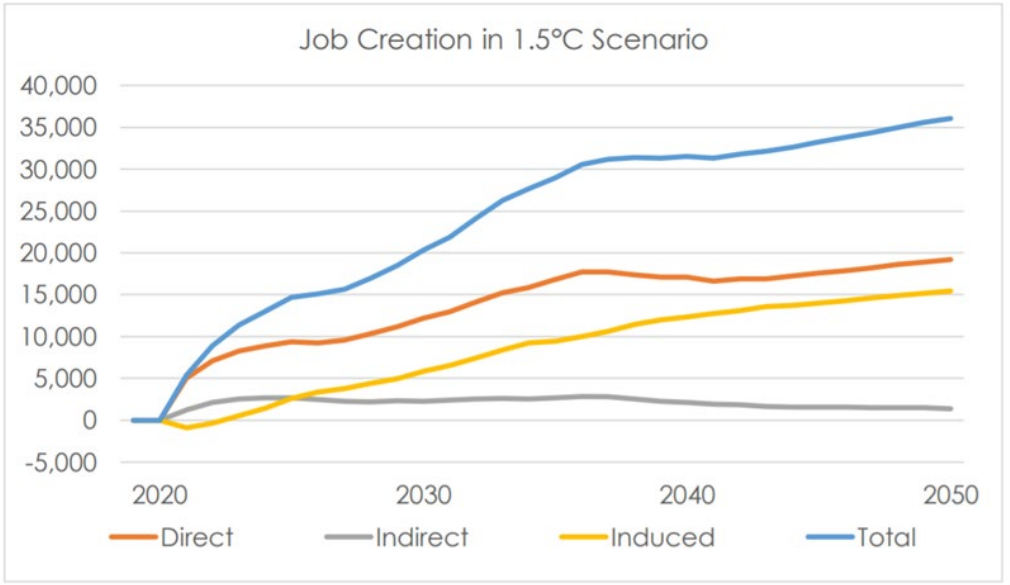
- Mid-term: post EV Plan 2025-2030
  - VCE: Modeling finds that the reduction in economy-wide GHG emissions are more than 36 percent by 2025 and 56 percent by 2030 (2005 baseline); the reduction in electricity sector GHG emissions are 53 percent by 2025 and 80 percent by 2030. (pg. 5)[cix]
  - CEO: By achieving its goal of 940,000 EVs by 2030, the State could see significant environmental benefits that include emission reductions. As noted in the 2018 Colorado Electric Vehicle Plan, Colorado could experience an annual reduction of ozone forming pollutants estimated at 800 tons of NOx, 800 tons of VOC, and up to 3 million tons of GHG. (pg. 6)[cx]
- Long-term: 100 percent transportation electrification - Post 2030
  - EDF: By 2040, a Colorado Advanced Clean Cars Plan could reduce NOx emissions by roughly 370 to 750 tons per year, depending on the scenario. (pg. 10)[cxi]
  - VCE: Modeling finds the reduction in economy-wide GHG emissions is 69 percent by 2040 (baseline 2005); the reduction in electricity sector GHG emissions is 88 percent by 2040. (pg. 5)[cxii]
  - Electric Vehicle Cost-Benefit Analysis (MJB&A – 2017): 98 percent PEV penetration needed to reduce light-duty GHG emissions in the state by 80 percent from 2005 levels (high growth scenario). (pg. 2)[cxiii]
  - MJB&A Cost Benefit Analysis (2019): GHG emissions from the light duty fleet in Xcel's territory were approximately 12.6 million tons in 2005. However, even without significant PEV penetration, baseline annual fleet emissions are projected to fall to 11.9 million tons by 2050, a reduction of 6 percent from 2005 levels. This projected reduction is based on turnover of the existing vehicle fleet to more efficient vehicles that meet more stringent fuel economy and GHG standards issued by the Department of Transportation and Environmental Protection Agency. Under the Baseline, PEVs are projected to reduce annual light duty fleet emissions by up to 4 million tons in 2050 compared to baseline emissions (-38 percent). Under the High EV Growth Scenario, annual GHG emissions in 2050 will be as much as 10.9 million tons lower than baseline emissions (-93 percent).[cxiv]

Study Information	Key Modeling Assumptions Across Scenarios	BAU	Ambitious	Med	Key Findings/Outputs	Key Data Sources Used
RMI Energy Policy Simulator (2021)[25]	Assumes: Switching to 100 percent clean electricity Rapidly increasing sales of ZEVs and trucks & reducing passenger VMT Shifting to efficient, all-electric buildings and appliances Moving away from fossil fuel use in manufacturing Reducing methane leakage from oil and gas, water treatment, and waste management sectors Improving land management and capture more carbon	"BAU" Existing policies + scheduled power plant retirements +improvements in building and transportation efficiency, and economic adoption of EVs	"1.5°C" Illustrative example; displays set of policies that State could use to achieve emission reductions limits warming to 1.5°C. Power Sector Clean Energy Standard (CES) – 80 percent carbon free generation in 2030; 100 percent in 2035 and thereafter Transportation 40 percent emissions reduction in transportation emissions by 2030; 940,000 LD EVs by 2030; All new LD cars and SUVs sold are electric by 2035; All new freight trucks sold are electric by 2045 (~1.5 million LD by 2030) 20 percent reduction in LD travel by 2050 (increased alt. mobility) Buildings - All buildings fully electric by 2030	"GHG Roadmap 2019" Includes policy options presented in GHG Roadmap (Legislation+ utility commitments+ executive action in 2019 and 2020) Power Sector Carbon free electricity standard (69 percent by 2030; 97 percent by 2050- CCS + decarbonized fossil generation+ phase out of coal gen in 2030, no new gas gen buildout; 6,000 MW of new solar and wind capacity) Transportation EV sales standard reaches 43 percent LD sales and 5 percent HD sales by 2030.	1.5°C Scenario -reduces Colorado's projected net emissions (including land use) 48 percent below the 2030 BAU projection and 85 percent below BAU by 2050 -avoids 50 percent cumulative emissions projected under 2050 BAU scenario -result in new 20,000 jobs through 2030 and 36,000 new jobs in 2050 -Gross State product could increase by $3.5 billion per year in 2030 and $7.7 billion per year in 2050	GHG Roadmap Scenario -Carbon free percentages from E3 modeling of CO GHG Roadmap's 2019 Action Scenario[26] 1.5°C Scenario -Adapted from EL US Wide scenario[27] -Transportation assumption from Navigant GHG Roadmap Modeling [28] Full methodology[29]

[25] https://energyinnovation.org/wp-content/uploads/2021/05/Colorado-Energy-Policy-Simulator-Insights.pdf
[26] See E3 Technical Appendix of the GHG Roadmap report for more information, https://drive.google.com/file/d/1215j7zfCsgE50msF_ZJt6ZUj0iG7Th3V/view?usp=sharing
[27] https://github.com/Energy-Innovation/eps-colorado/raw/main/Colorado%20EPS%20Scenario%20Assumptions.pdf
[28] See page 134 of the GHG Roadmap Report for more information.
[29] https://colorado.energypolicy.solutions/scenarios/hom

			Deep retrofit 15 percent of buildings by 2050 Enhanced efficiency standards (ranging 11-40 percent energy savings by end use) Industrial All end-uses switch too zero-carbon fuel where possible	Buildings 60 percent building electrification by 2030, 95 percent electrification by 2050	-Prevent more than 350 deaths and more than 10,000 asthma attacks per year by 2030 and more than 1,400 deaths and nearly 44,000 asthma attacks by 2050. Monetized health and other social benefits would reach $21 billion annually by 2050.	





Projected changes in jobs relative to BAU in the 1.5°C Scenario

Study Information	Key Modeling Assumptions Across Scenarios	BAU	Ambitious	Med	Key Findings/Outputs	Key Data Sources Used
E3 Colorado GHG Pollution Reduction Roadmap[30]	-2015 Colorado emissions used as benchmark -utilized E3 pathways model "bottom-up" accounting of all-energy consuming devises -for transportation and building sector, bottom-up stock rollover approach utilized -Electric sector modeled using E3 RESOLVE model with utilized least-cost electricity generation portfolios that achieve 80 percent emissions reductions by 2030 -Core scenarios are based on pre-Covid conditions-additional sensitivities were conducted to evaluate potential impact including: low population growth, reduction in VMT, flat oil and gas production	"Reference Scenario" Sector-specific policies adopted before 2019 legislative session (e.g., RPS, CAFE standards for passenger vehicles) Power Sector -existing RP, announced coal retirements Building -utility efficiency programs, existing appliance standards Transportation -Efficiency: CAFE Standards -Electrification: EIA AEO 2019 Reference Forecast Low-carbon Fuels -Existing ethanol and biodiesel blends	"HB-1261 Targets Scenario" Illustrative scenario to reduce emissions by 25 percent, reducing 2030 by 50 percent and 2050 emissions by 90 percent from 2005 levels. Power Sector -Same as 2019 Action Scenario Building -appliance efficiency standards for all end uses, efficient building shell requirements -highest electrification for all end-uses Transportation -Efficiency: CAFE Standards; LDV VMT reductions -Aggressive ZEV Sales for all vehicle types Low-carbon Fuels -Advanced biofuels and hydrogen production	"2019 Action Scenario" -Key policies adopted during 2019 (e.g., electric sector GHG emissions target (JB19-1261); social cost of carbon in electric sector planning (SB19-236) increased efficiency standards (HB10-1231); creation of ZEV (E O B 2019 001) Power Sector -80 percent reduction in pollution from CO generation by 2030; 95 percent by 2050 including Xcel & tristate commitments and HB 1261 Building -appliance efficiency standards covered under HB 1231 Transportation -Same EE as Reference -ZEV Standard for LDV State EV plan target of 940,000 EVs by 2030- -ramp up of sales of ZEV to 70 percent by 2030 Low-carbon Fuels -Same as reference	- LD Vehicle electrification costs savings of \$172/tonne CO_2-e in 2030 compared to the reference	-Transportation and building sector data from EIA NEMS model validated by benchmarking "top-down" energy consumption data from Colorado -Roadmap inventories use 100-year GHG GWP to translate methane to CO_2-e, based on IPCC AR5 Methods

[30] https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap

Figure 21: E3 Modeling Framework

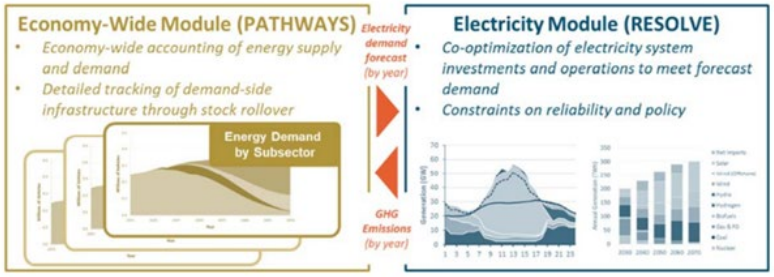
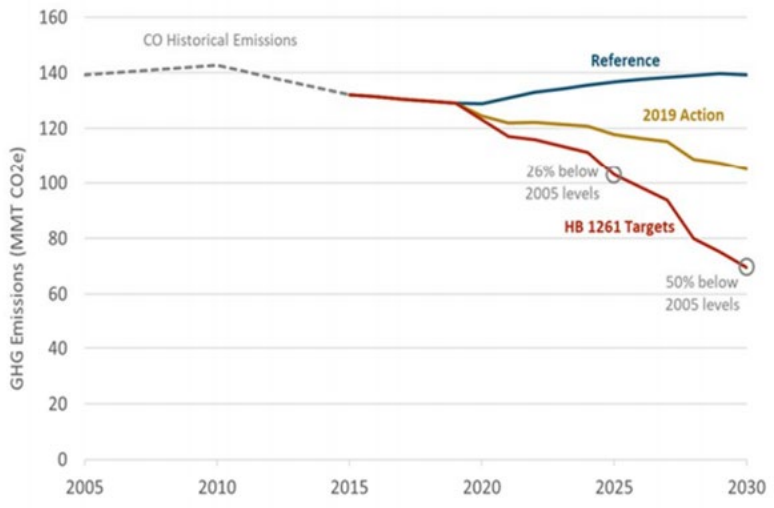


Figure 22: E3 GHG Emissions Projections by Scenario Through 2030

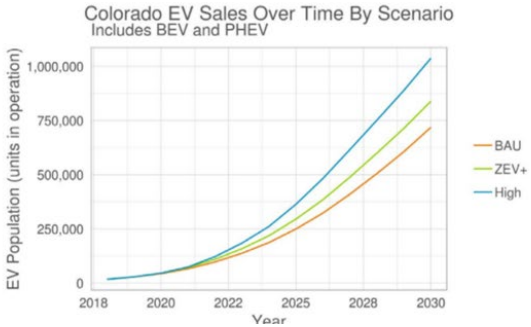


Study Information	Key Modeling Assumptions Across Scenarios	BAU	Ambitious	Med	Key Findings/Outputs	Key Data Sources Used
Colorado Electric Vehicle Plan 2020[31] *(Navigant Consulting Electric Vehicle Growth Analysis (2019)[32])*		"Scenario BAU" Existing policies + infrastructure investment Incentives Description: Continued tax credit Magnitude: Based on legislation Timing: Continued through 2025, with ratchet down over time Public Infrastructure Description: Infrastructure investment Magnitude: $200M with 11,000 L2 and 1,280 DCFC ports by 2030 Timing: Over 10 years, starting 2020 Marketing No change Model Availability	"Scenario High" Medium + accelerated ZEV, LCFS $2,000 incentive + additional marketing + higher infrastructure investment Incentives Description: Continued tax credit + LCFS Magnitude: Based on legislation + additional $2,000 from LCFS Timing: Continued through 2025, with ratchet down over + LCFS 2022-2030 Public Infrastructure Description: Infrastructure investment Magnitude: $300M with 58,000 L2 and 2,500 DCFC ports by 2030 Timing: Over 10 years, starting 2020 Marketing Description: Larger marketing campaign + global awareness increase Magnitude: High	"Scenario ZEV+" BAU + ZEV Adoption + Marketing Campaign Incentives *Same as BAU* Public Infrastructure *Same as BAU* Marketing Description: Marketing campaign Magnitude: Medium Timing: 2-3 year campaign, starting in Q3 2020 Model Availability	PEV Potential Under the BAU scenario, Colorado is expected to reach about 719,000 PEVs in operation by 2030 With implementation of the policies in the High scenario, it could be possible for Colorado to exceed 940,000 PEVs in operation by 2030 Incentives The continued State tax credit reduces the TCO for PEVs and coincides with the period when national incentives are expected to ramp down. The LCFS incentive also helps reduce the TCO and offset the reduction of the national incentives in the High scenario. Infrastructure Infrastructure investments remove market barriers to adoption, particularly for certain customer segments.	CEO 2020 report references: -Study conducted on behalf of CEO in 2019 by MJB&A examined utility bill impacts -ICCT study conducted on behalf of CEO in 2018 examined EV price impacts to Coloradans as a result of a ZEV rule adoption -ICCT 2019 study projected EV growth across the US and charging gaps needed to support the anticipated growth – concluded that the Denver metropolitan

[31] https://energyoffice.colorado.gov/sites/energyoffice/files/2020-07/colorado_ev_plan_2020_-_final.pdf
[32] https://drive.google.com/file/d/1ulRw0Yfjz53nbvBjWQO14z_4jLsqzK4z/view

		No change Found PEV population in 2030 to be ~719,000 vehicles	Timing: 2-3 year campaign, starting in Q3 2020 Model Availability Description: Model availability increase Magnitude: ZEV standard Timing: Starting in 2020 (MY 2021) Found PEV population in 2030 to be ~1,038,000 vehicles	Description: Model availability increase Magnitude: ZEV standard Timing: Starting in 2022 (MY 2023) Found PEV population in 2030 to be ~839,000 vehicles	Additional chargers reduce range anxiety, lead to higher visibility of PEVs, facilitate greater awareness, and increase eligibility for residents of multi- family dwellings. Additional *takeaways listed for ZEV Status, Policies, and Timing of New Policies in report*.	area is forecast to have only a fraction of what will be needed. --- Navigant: -Vehicle Adoption Simulation Tool (VAST) Adoption Module

Results – PEV Population

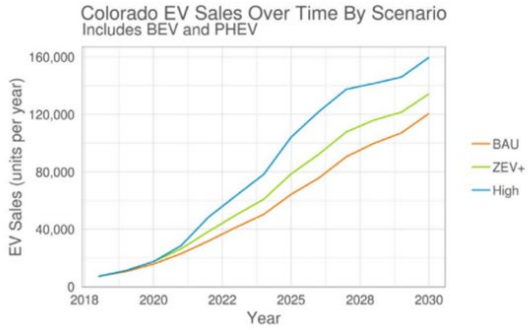


PEV Population – Units in Operation

Percentage of Total Population

Scenario	2020	2025	2030
BAU	43,346	249,683	718,787
	0.8%	*4.1%*	*10.2%*
ZEV+	45,701	295,223	838,997
	0.8%	*4.8%*	*11.9%*
High	45,701	363,692	1,037,586
	0.8%	*5.9%*	*14.8%*

Results – PEV Sales



PEV Sales – Units per Year

Percentage of Total Sales

Scenario	2020	2025	2030
BAU	15,630	64,260	120,598
	5.3%	*21.1%*	*38.2%*
ZEV+	17,342	78,519	134,311
	5.9%	*25.8%*	*42.5%*
High	17,342	104,175	159,669
	5.9%	*34.2%*	*50.5%*

Study Information	Key Modeling Assumptions Across Scenarios	BAU	Ambitious	Med	Key Findings/Outputs	Key Data Sources Used
EDF Colorado ZEV Report (2019)[33]	*See image in next row for assumptions, see report for additional tables on assumptions (e.g., maintenance costs)* -CO ZEV Program Credit Requirements for MY2023, 2024, and 2025+ -Baseline used for all the modeling runs in this report reflects the U.S. EPA Tier 3 light-duty vehicle criteria emissions standards - For GHG emissions, the baseline holds constant EPA's light-duty vehicle GHG standards for MY 2020, based on the Trump Administration proposal in August 2018 to freeze the GHG standards at MY 2020 levels -Assume Colorado to be part of the national Tier 3 and GHG programs -Assume that OEMs will average the zero ZEV tailpipe emissions with gasoline vehicle emissions to achieve overall fleetwide compliance -ICCT estimates that a 50 percent BEV150 / 50 percent BEV250 mix had an average electricity consumption rate of about 0.36 kWh/mi in 2018 to 0.33 kWh/mi in 2030 // PHEV50s, when operating on grid electricity, had an	"Scenario 1" Combination of the Colorado ZEV program, the Colorado Low Emission Automobile Regulation (CLEAR) tailpipe criteria and CLEAR GHG standards adopted by Colorado beginning in MY 2022; OEMs seek to fully exploit averaging with respect to CLEAR GHG compliance, using additional ZEV sales to sell higher GHG emitting gasoline vehicles than would be possible absent the ZEV program	"Scenario 3" Equivalent to Scenario 2 through 2025, then post-2025 ZEV growth scenario building off "low" scenario where ZEV market share is assumed to grow by an absolute 3 percent per year from 2026-2035 (no gasoline vehicle averaging with the higher ZEV sales) Results: -Could achieve >100,000 additional electric vehicle sales by 2035 compared to a baseline where the State does not adopt a ZEV program -Results in new ZEV market share increasing from 7.4 percent in MY 2025 to 37 percent in MY	"Scenario 2" Combination of the Colorado ZEV program, the CLEAR tailpipe criteria and CLEAR GHG standards adopted by Colorado beginning in MY 2022; OEMs do NOT exploit any GHG averaging with higher ZEV sales under ZEV program Assume that gasoline vehicle criteria emissions will not increase over time due to averaging with higher ZEV sales	-Save Coloradans up to $65 million annually by 2025 and up to $2.2 billion a year by 2040, in economic and pollution benefits (*see report for detailed cost savings)* -Avoid 1 million metric tons of GHG emissions every year by 2025 and up to 7.6 million tons annually by 2040, equivalent to taking more than 200,000 cars off of Colorado's roads in 2025 and removing nearly 1.6 million cars in 2040 -Significantly reduce ozone forming pollution and harmful particulate pollution, avoiding up to 10 premature deaths annually and 670 lost workdays avoided each year by 2050 -Under all scenarios, Colorado would realize an increase (relative to the baseline) of more than	-EIA's 2019 AEO's Reference Case for gasoline and electricity price projections -Analysis sponsored by NRDC to project ZEV sales for baseline (no ZEV program) (proprietary estimates by Alan Baum and Associates)[34] -ICCT analysis for cost estimates and kWh/mile projections[35] -EPA analyses for the Proposed and Final Determinations in 2016 and 2017 for VMT, insurance and maintenance costs -EPA OMEGA for fuel costs

[33] http://blogs.edf.org/climate411/files/2019/08/FINAL-EDF-Colorado-ZEV-report-2019.pdf
[34] https://docs.wixstatic.com/ugd/6fe7f1_eeca19bd30f74933814fbec8f6f8d8ab.pdf
[35] https://theicct.org/publications/update-US-2030-electric-vehicle-cost

	average rate of 0.38 kWh/mi in 2018 to 0.35 kWh/mi in 2030. -ICCT estimates that PHEV50s would operate 69 percent on battery electricity, and the remainder of the time on gasoline with an average fuel economy of 47 mpg in 2018 to 56 mpg in 2030 -VMT use a rebound effect of 10 percent for new, more efficient gasoline vehicles: BEV150s are assumed to travel 93 percent of the annual VMT of a comparable gasoline vehicle, and BEV250s are assumed to drive 97 percent of gasoline vehicle VMT -Uses AEO's Reference Case electricity (for transportation) prices of $0.119/kWh in 2018 and $0.124/kWh in 2050 -Incremental insurance costs are 1.9 percent of the initial incremental vehicle cost in the first year and decrease each year consistent with the vehicle's residual value -All future costs/savings discounted at a 3 percent annual rate back to the year when the new vehicle is introduced into the fleet -Assumed that 25 percent of incremental energy demand associated with ZEVs in Colorado would be met by natural gas and 75 percent would come from renewables. -Gasoline prices of $3.00/gallon in 2020 to $3.66/gallon in 2050 (also show high gas price sensitivity where prices are $1-2/gallon higher)	Assume that gasoline vehicle criteria emissions will not increase over time due to averaging with higher ZEV sales	2035 (relative to baseline of 2.9 percent)		8,400 ZEV sales by 2025 as a result of adopting a ZEV program	

Colorado Light-Duty Vehicle Regulatory Scenarios

SCENARIO	CRITERIA EMISSIONS		GREENHOUSE GAS EMISSIONS		ZEV ASSUMPTIONS
	TAILPIPE STANDARD	AVERAGING WITH HIGHER ZEV SALES	TAILPIPE STANDARD	AVERAGING WITH HIGHER ZEV SALES	
BASELINE	EPA TIER 3	YES	EPA 2020	YES	NO ZEV PROGRAM
1	CLEAR	NO	CLEAR	YES	CO ZEV
2	CLEAR	NO	CLEAR	NO	CO ZEV
3	CLEAR	NO	CLEAR	NO	CO ZEV + ZEV GROWTH MY 2026-2035

Projected ZEV Sales in Colorado Under Colorado Advanced Clean Car Program Scenarios

MODEL YEAR	BASELINE		SCENARIOS 1 AND 2				SCENARIO 3			
	TOTAL		TOTAL		INCREMENTAL		TOTAL		INCREMENTAL	
	%	#	%	#	%	#	%	#	%	#
2023	3.1	8,594	5.6	15,589	2.5	6,995	5.6	15,589	2.5	6,995
2024	3.8	10,491	6.4	18,069	2.7	7,578	6.4	18,069	2.7	7,578
2025	4.4	12,374	7.3	20,788	2.9	8,414	7.3	20,788	2.9	8,414
2030	4.4	12,681	7.3	21,307	2.9	8,626	22.3	65,055	17.9	52,374
2035+	4.4	13,460	7.3	22,615	2.9	9,155	37.3	115,487	32.9	102,027

* NOTE THAT SOME VALUES MAY NOT PRECISELY SUM DUE TO ROUNDING

Study Information	Key Modeling Assumptions Across Scenarios	BAU	Ambitious	Med	Key Findings/Outputs	Key Data Sources Used
Colorado Electrification & Decarbonization Study[36] (Vibrant Clean Energy (VCE), LLC – 2019)[37]	*Electricity grid mix provided in study* NREL EFS: -Up to 80 percent of ground-based transportation electrified through BEV, HEVs, FCEVs by 2040 -20 percent assumed to continue to be ICE vehicles WIS:dom® optimization model: -Enough electricity in EVs at all times for a standard commute (40-mile round trip) -Builds the electricity requirements for each county based on the number of EVs within the county -Input profiles scaled based on daily weather -Allows charging to be interrupted/ shifted (assumes all electricity restored within 36 hours, before if the amount of stored electricity is not enough to cover round trip commutes (pays customer $60/ MWh to shift charging) -Efficiency improvements (3.75 miles/kWh in 2018, 5 miles/kWh by 2040 for EVs; 28.5 mpg in 2018, 40 mpg by 2040 for ICE) -Average number of miles driven assumed to be 10,000 miles	"BAU" Coal generation through 2040. The other sectors are defined using a Colorado GHG inventory report.	"Deep Decarbonization" Electrifies other CO economic sectors from 2018-2040[38]	"Retire Coal" Retires all plants in CO and drives all other electricity sector decisions economically. (Others are defined as "BAU counterfactual" scenario)	-Electrifying other sectors will allow CO to meet the HB19-1261 GHG emission targets through 2040, while lowering energy costs -Total economy-wide emissions reduction for the deep decarbonization scenario by 2040 is 70 percent below 2005 levels -Transportation fuel costs are reduced by $610 annually per customer -Total savings between 2018 and 2040 for transportation are estimated to be $15.6 billion (real 2017$), ~$680 million per year -Average cost of energy for vehicles: $886 annual cost under BAU, $256 under Deep Decarbonization -The electricity rates are lower than the BAU counterfactual and retire coal scenarios for all investment periods; implies that customers who do not electrify are not burdened with additional costs	-NREL Electricity Futures Study "high (moderate advancement) dataset -WIS:dom® optimization model/ WIS:dom® high resolution weather dataset -Colorado GHG Inventory – 2014 Update (CDPHE) -Cost of gasoline from EIA AEO 2019 projections

[36] Basis of study is examining changes in the electricity grid and retirement of coal – electrification of heating and transportation is a component but not the central element.

[37] https://www.vibrantcleanenergy.com/wp-content/uploads/2019/11/CEDS-CEI-VCE-FullReport.pdf

[38] Expanded upon EV grid scenario from previous VCE study: https://www.vibrantcleanenergy.com/wp-content/uploads/2019/08/CES-CE_VCE.pdf

Average assumed charging requirements of an EV in Colorado

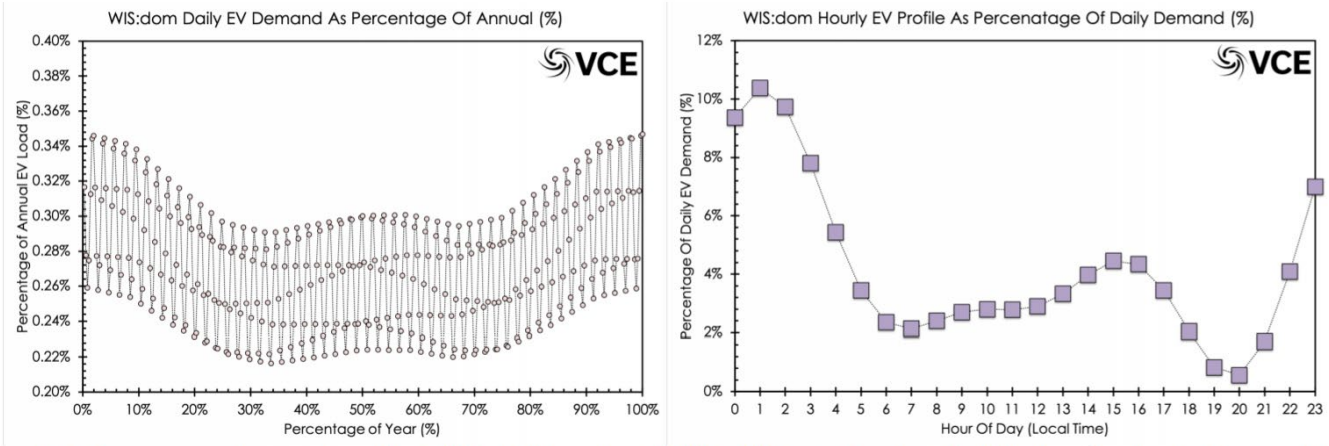


Figure 2.2: The average demand profiles (daily, left; hourly, right) for EVs in Colorado. The WIS:dom® optimization model can shift the charging if it is deemed appropriate.

Study Information	Key Modeling Assumptions Across Scenarios	BAU	Ambitious	Med	Key Findings/Outputs	Key Data Sources Used
ICCT Colorado (2021)[39]	-New EVs include battery electric and plug-in hybrid EVs with 20 percent representing battery electric and 80 percent representing plug-in hybrid EV sales assumed -EV stock is calculated from new EV sales and fleet stock turnover model (see appendix A of report) -Builds out county-level data for EV sales and stock -For county-level EV sales projections, the report uses county-specific EV sales projection based on 2019 county sales data and the statewide annual growth rate -For county-level EV stock, the report uses differences in vehicle ownership used in 2018 like general density, housing, and vehicle ownership patterns throughout the state -Public charging growth assumptions: 20 percent of public chargers are Level 2 and 20 percent are DC fast -Home charging assumptions: 80 percent of all EV owners have access to residential charging		-High growth scenario: CO's goal of 70 percent EV sales by 2030; 940,000 EV stock by 2030	- Low growth scenario: 42.5 percent EV sales by 2030; 580,000 EV stock by 2030	-For the high growth scenario public chargers will need to increase from ~2,100 in 2020 to ~24,000 in 2030 -For the low growth ~1,600 public chargers will be needed by 2030 -For both the high growth and low-growth scenarios home chargers will represent about 85 percent of chargers in CO by 2030 -For the high growth scenario 437,000 home chargers are needed by 2030 -For the high growth scenario ~9.9 GWh of electricity will be needed daily for EV charging in 2030, about 6 percent of the statewide energy consumption -Charging infrastructure costs will increase by about $860 million from 2021 to 2030	- Gil Tal, Jae Hyun Lee, and Michael Nicholas, Observed charging rates in California, (Institute of Transportation Studies: Davis, CA, 2018)[40] - Colorado Energy Office, "Colorado EV Plan 2020" (2020)[41] - Colorado Energy Office, "Colorado Greenhouse Gas Pollution Reduction Roadmap" (September 30, 2020)[42] - "State EV registration data," Atlas Public Policy (accessed October 2020)[43] - Charging infrastructure data (accessed October 2020)[44]

[39] https://theicct.org/publications/colorado-charging-infra-feb2021
[40] https://escholarship.org/uc/item/2038613r
[41] https://energyoffice.colorado.gov/zero-emissionvehicles/colorado-ev-plan-2020
[42] https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap
[43] https://www.atlasevhub.com/materials/State-ev-registration-data/
[44] https://www.plugshare.com

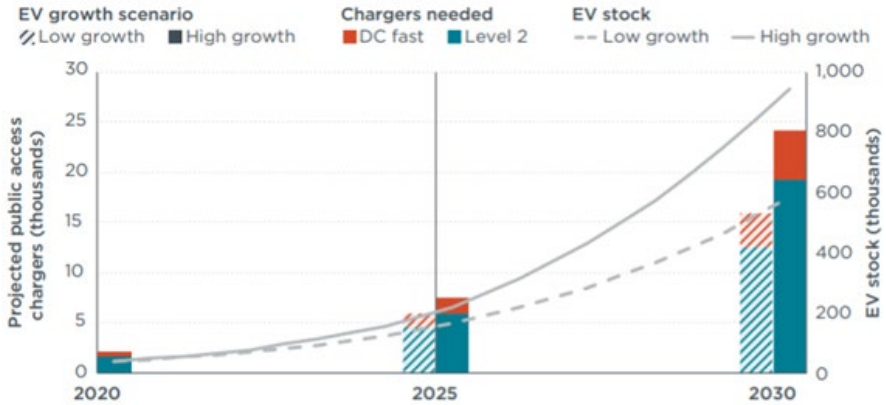


Figure 2. Colorado statewide public charging infrastructure needed under high-growth (70% EV sales by 2030) and low-growth (42.5% EV sales by 2030) scenarios.

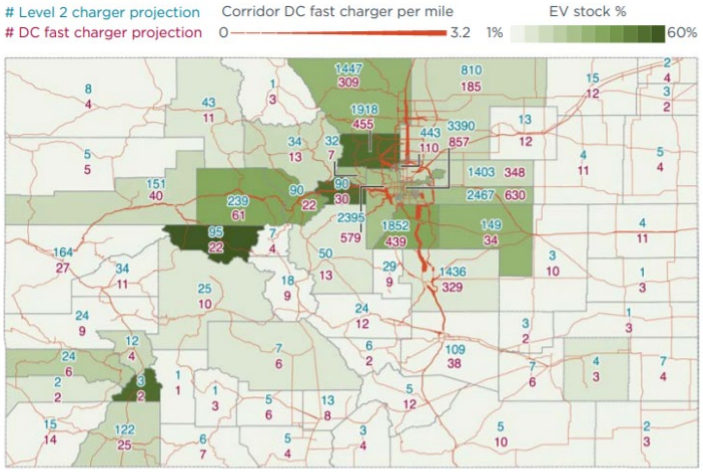


Figure 3. 2030 county-level public Level 2 (blue numbers) and DC fast (red numbers) chargers needed and share of EV stock, based on the high-growth scenario.

Study Information	Key Modeling Assumptions Across Scenarios	BAU	Ambitious	Med	Key Findings/Outputs	Key Data Sources Used
Initial Economic Impact Analysis[45] (This is an Economic Impact Analysis of implementing CLEAR requirements)	-Only Battery Electric Vehicles (BEV) and Plug-in Hybrid Electric Vehicles (PHEV) used in this analysis for compliance with Colorado Low Emission Automobile Regulation (CLEAR) requirements -CLEAR requirements in "Colorado Regulatory Compliance Scenario" table below; CLEAR sets minimum ZEV credit percentage requirements for vehicle manufacturers from MY years 2023 to 2030 -Use production averaging for ZEV requirements: "The number of vehicles to which the credit percentage ZEV requirement is applied for the given model year is based on the three-year average of the manufacturer's volume of passenger cars ("PCs") and light-duty trucks ("LDTs") produced and delivered for sale in Colorado in the prior second, third, and fourth model year. For example, 2023 model year ZEV requirements will be based on Colorado production volume average of PCs and LDTs for 2019 to 2021 model year." -Primary costs and benefits analyzed in the proposal include upfront cost for BEVs and PHEVs, costs of operation, and maintenance and repair				Costs (maintenance and fuel) -Total maintenance savings from 2023 to 2030 equal about $699.57 million (net present value of $597.57 million using a 3 percent compounded interest rate) -Total fuel cost savings from 2023 to 2030 would equal about $734.68 million (net present value of $624.64 million using a 3 percent compounded interest rate) Benefits (emissions reductions) -The proposed ZEV program will create an emissions reduction of 2.2 million metric tonnes or 2.4 million tons of GHGs by 2030 -The proposed ZEV program will create an emissions reduction of 18,721 metric tonnes of carbon monoxide emissions by 2030 -A cost savings of $520 per metric tonne was found for GHG emissions reductions and $60,022 per metric tonne	-Colorado Department of Public Health and Environment's CO ZEV Calculator (Based off of CARB's 2017 ZEV Calculator) and Cost and Benefit Calculator -New vehicle sales estimations were based off the Colorado Department of Revenue, Colorado Automobile Dealer Association, and the Alliance of Automakers among other sources -Costs used come from 2019 U.S. Department of Energy Annual Energy Outlook (AEO) fuel prices, U.S. DOE Energy Information Administration, internal utility emissions data and rates, U.S. DOE Alternative Fuels Data Center, and U.S. EPA, among others - U.S. EPA fuel economy data

[45] Colorado Department of Public Health and Environment Air Pollution Control Division: AQCC Regulation Number 20: Zero Emission Vehicle Initial Economic Impact Analysis

	-Assume 5 percent growth in range annually for BEVs starting at 192.5 miles per charge in MY 2018 and for non-US06 PHEVs range reaches 55 miles per charge starting in MY 2023 -Assume a ZEV vehicle mix of 75 percent BEV and 25 percent PHEV -Use market shares of 25 percent for car, 37.5 percent for crossover, and 37.5 percent for SUV - PHEVs operated 75 percent on electric batteries and 25 percent on gasoline power -Most charging will be at home level 2 charging paying residential electric rates of 12.14 cents per kWh and public fast charging 10 percent of the time at 28 cents per kWh -Maintenance costs: Operating costs of 6 cents per mile for cars and 7.6 cents per mile for SUVs for conventional ICE vehicles; Maintenance and repair costs for BEVs were assumed to be 2.4 cents for cars and 3.6 cents per mile for SUVs. Maintenance and repair costs for PHEVs were assumed to be 4.2 cents per mile for cars and 5.5 cents per miles SUVs -Vehicle life of 150,000 miles -GHG assumptions: GWP of 28 for methane				of carbon monoxide emissions reductions Cost/Benefit Ratio -This analysis found a negative cost/benefit ratio, which means there is an overall savings related to the ZEV program	

Key Findings:

Colorado Regulatory Compliance Scenario

Model Year	Light-duty Vehicle Sales	BEV	PHEV	Total	% of Total
2023	277,992	9,767	3,717	13,484	4.85%
2024	280,772	11,437	4,111	15,548	5.54%
2025	283,580	13,140	4,482	17,622	6.21%
2026	286,416	13,278	4,374	17,652	6.16%
2027	289,280	13,417	4,268	17,685	6.11%
2028	292,173	13,558	4,171	17,729	6.07%
2029	295,094	13,701	4,213	17,914	6.07%
2030	298,045	13,845	4,255	18,099	6.07%

Cumulative Cost Savings of the Proposal - Net Present Value (in million $)

	Incremental Vehicle Cost			Fuel Cost Savings		Maintenance Savings	
Model Year	BEV	PHEV	Total	Lifetime Average	First 5 Years Average	Lifetime Average	First 5 Years Average
2023	-$61.57	-$24.01	-$85.57	$59.08	$31.90	$58.45	$32.51
2024	-$53.04	-$25.45	-$78.49	$67.93	$35.90	$67.82	$37.72
2025	-$41.21	-$26.62	-$67.82	$77.86	$40.87	$77.29	$42.98
2026	-$23.64	-$24.94	-$48.59	$79.88	$42.23	$77.70	$43.21
2027	-$7.43	-$23.39	-$30.82	$81.81	$43.51	$78.12	$43.45
2028	$7.56	-$21.99	-$14.43	$83.67	$44.71	$78.57	$43.70
2029	$21.47	-$21.38	$0.09	$86.06	$46.16	$79.39	$44.15
2030	$35.84	-$20.81	$15.03	$88.35	$47.52	$80.22	$44.62
Total 2023-2025	**-$155.81**	**-$76.07**	**-$231.89**	**$204.87**	**$108.67**	**$203.56**	**$113.21**
Total 2026-2030	**$33.79**	**-$112.51**	**-$78.72**	**$419.77**	**$224.13**	**$394.01**	**$219.13**

Greenhouse Gas Benefit (metric tonnes/year)

Model Year	Total GHG All Vehicle
2023	217,972
2024	235,270
2025	251,106
2026	264,373
2027	277,449
2028	290,471
2029	305,505
2030	320,499
Total	**2,162,646**

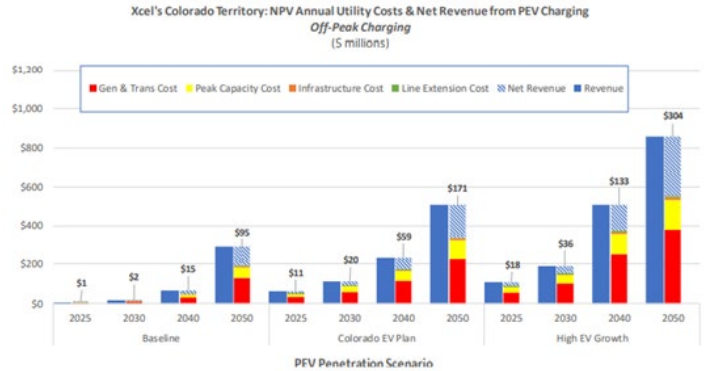
Study Information	Key Modeling Assumptions Across Scenarios	BAU	Ambitious	Med	Key Findings/Outputs	Key Data Sources Used
MJB&A Electric Vehicle Cost-Benefit Analysis (2019)[46]	-Considered two different electricity rates: 1) a standard electricity rate which is charged to Xcel's customers for every hour of the day (currently $0.11/kilowatt-hour (kWh)), which was applied to all EV charging under the baseline scenario, and 2) a Time of Use (TOU) rate ($0.08/kWh) which was applied for EV charging under the "Off-Peak Charging" scenario - increased capacity costs ($/kW-month) used came from Xcel Energy's Demand-Side Management Annual Status Report (2017) and assume the following values: $10.29 in 2025, $11.53 in 2030, $14.40 in 2040, and $17.08 in 2050 -the construction allowance is $385/kW of load based upon comparison of current policy versus new ($350/kW vs $735/kW)	Baseline: -Penetration of PEVs will follow similar patterns to the states in the ZEV Memorandum of Understanding - 10 percent of annual light duty vehicle sales in Colorado to be ZEV by 2025 -After 2025, PEV penetration is assumed to be 1 percent in 2025, 2 percent in 2030, 8 percent in 2040, and 33 percent in 2050 - the number of PEVs registered in Xcel's service area would increase from approximately 11,600 today to 35,400 by 2025, 77,800 in 2030, 343,000 in 2040, and 1.5 million in 2050	High EV Growth: -PEV penetration required to achieve an economy wide GHG emission reductions of 80 percent from 2005 levels by 2050 - PEV penetration is assumed to be 16 percent in 2025, 26 percent in 2030, 60 percent in 2040, and 88 percent in 2050 - 920,000 PEVs in Xcel's service area by 2030, 2.4 million in 2040, and 4.0 million in 2050 -electricity used for PEV charging is projected to be 1.5 million MWh in 2025 and 12.4 million MWh in 2050 - NPV of revenue utilities would realize from selling additional	Colorado EV Plan: - PEV penetration required to achieve Colorado's EV Plan goal of 940,000 EVs by 2030 and a modest increase for rate of growth in post-2030 EV sales - PEV penetration is assumed to be 10 percent in 2025, 15 percent in 2030, 29 percent in 2040, and 56 percent in 2050 - the number of PEVs registered in Xcel's service area would increase to 308,400 by 2025, 545,000 in 2030, 1.2 million in 2040, and 2.5 million in 2050 -electricity used for PEV charging is projected to be 0.9 million MWh in 2025	Under the baseline charging scenario: -Under the Baseline scenario, the NPV of annual net revenue is projected to be slightly negative in 2025, but quickly turns positive and eventually rising to $74 million in 2050 -Under the Colorado EV Plan scenario, the NPV of annual utility net revenue from PEV charging is projected to total $3 million in 2025, rising to $135 million in 2050 -For the High EV Growth scenario, the NPV of annual utility net revenue from PEV charging is projected to total $5 million in 2025, rising to $258 million in 2050 Under the off-peak charging scenario: -Under the Baseline scenario, the NPV of annual utility net revenue is $0.9 million in 2025 and $20.9 million in 2050 due to lower utility costs -For the Colorado EV Plan scenario, off-peak charging will increase the NPV of annual utility	-National Renewable Energy Laboratory's Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite

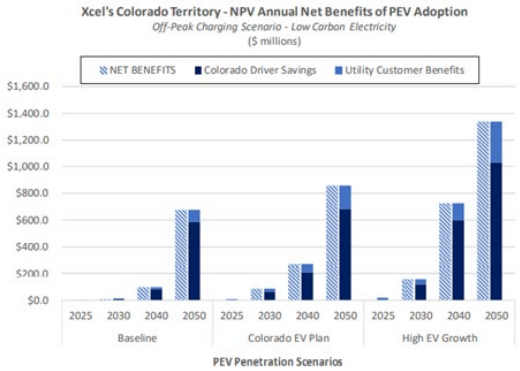
[46] The table summarizes the 2019 update for MJB&A's cost benefit analysis; however, it is not currently available online. The 2017 version is available here.

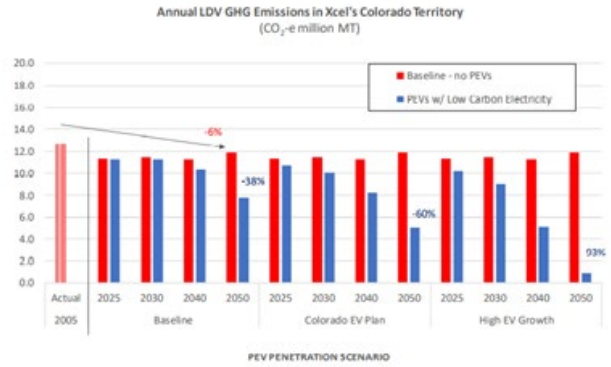
	-average load for a L2 port is assumed to be 6.2 kW while load for a DCFC port is assumed to be 105 kW -Two different PEV charging scenarios: 1) a baseline scenario in which all PEVs are plugged in and start to charge as soon as they arrive at home each day, and 2) an off-peak charging scenario in which a significant portion of PEVs that arrive home between noon and 8:00 PM each day delay the start of charging until after 9:00 PM -Electric grid will be about 50 percent zero emission generation in 2025, 80 percent in 2030, 90 percent in 2040, and 100 percent renewable generation in 2050 -Costs are in NPV using a 3 percent discount rate - There are currently 2.7 million light-duty vehicles registered in Xcel Energy's Colorado service area, and these vehicles travel 28.5 billion miles per year; both the number of vehicles and total annual vehicle miles are projected to increase by 56 percent through 2050 to 4.6	- electricity used for PEV charging is projected to be 0.1 million MWh in; 4.2 million MWh by 2050 -NPV of revenue utilities would realize from selling additional electricity for PEV charging is projected to be negative in 2025 at approximately $27,400 but quickly rises after that reaching $74 million in 2050 -NPV for line-extension costs are projected to total $0.9 million in 2025, rising to $4.7 million in 2050 - annual cost savings from greater PEV ownership are projected to be negative $5 million in 2025 but quickly rise to a positive $9 million in 2030, $83 million in 2040 and $585 million in 2050 - the low carbon electricity grid in 2050	electricity for PEV charging is projected to be $5 million in 2025, rising to $258 million in 2050 -NPV for line-extension costs are projected to total $7.0 million in 2025, rising to $8.7 million in 2040, but then slowly decline to $5.8 million in 2050 - the NPV of total annual cost savings to drivers from greater PEV ownership are projected to be negative $75 million in 2025, but rise to a positive $120 million in 2030, $595 million in 2040 and $1 billion in 2050 - Under the High EV Growth Scenario, annual GHG emissions in 2050 will be as much as 10.9 million tons lower than baseline emissions (-93 percent)	and 7.4 million MWh by 2050 - NPV of revenue utilities would realize from selling additional electricity for PEV charging is projected to be $3 million in 2025, rising to $135 million in 2050 -NPV for line-extension costs are projected to total $4.0 million in 2025, increasing to $6.0 million in 2050 - the low carbon electricity grid in 2050 under the CO EV Plan scenario will reduce annual NOx emissions by approximately 318 metric tons compared to continued use of conventional vehicles	net revenue by $7.4 million in 2025 and $36 million in 2050 -Under the High EV Growth scenario, off-peak charging will increase the NPV of annual utility net revenue by $12.5 million in 2025 and $47 million in 2050 Under the baseline charging scenario: - the NPV of annual economic benefits are projected to be a minimum of $659 million per year in 2050 under the Baseline and $1.3 billion per year in 2050 under the High EV Growth scenario - Approximately 80 percent of these annual benefits will accrue to Colorado PEV drivers as a cash savings in vehicle operating costs, and 20 percent will accrue to electric utility customers as a reduction in annual electricity bills Under the off-peak charging scenario: - the NPV of annual savings will be $680 million, an increase of $21 million under the Baseline scenario. If Colorado is successful in implementing the Colorado EV plan goal of putting 940,000 EVs on the road by 2030 and continues this growth through 2050, the NPV of annual savings will total $857 million, an increase of $36 million	

	million light duty vehicles traveling nearly 45 billion miles annually - assumed that battery prices would be $125/kWh in 2025, slowly falling to $80/kWh in 2050 - assumes that 60 percent of PEVs will be BEV and 40 percent will be PHEV	under the Baseline scenario will reduce annual NOx emissions by approximately 107 metric tons compared to continued use of conventional vehicles	- the low carbon electricity grid in 2050 under the High EV scenario will reduce annual NOx emissions by approximately 857 metric tons compared to continued use of conventional vehicles		compared to baseline charging under the Colorado EV Plan scenario, total annual savings (NPV) in 2050 will be $1.3 billion under the High EV Growth scenario if Colorado PEV drivers charge off-peak and the State is successful in decarbonizing the electric grid, an increase of $47 million as compared to baseline charging	

Key costs/benefits







APPENDIX C KEY ELEMENTS OF THE INFRASTRUCTURE INVESTMENT AND JOBS ACT / BIPARTISAN INFRASTRUCTURE LAW AND THE PROPOSED BUILD BACK BETTER PROGRAM

Category	Provision Number	Details	Funding Amount	Timeline
Authorizations and Programs	Sec. 11109 Surface transportation block grant program	Establishes a program that provides flexible funding to States and localities to address transportation-related needs. Funds are first appropriated to States and then directed to metropolitan planning organizations (MPOs). This program, among other items, supports the installation of electric vehicle charging infrastructure and vehicle-to-grid infrastructure. This provision establishes a set aside of 55 percent for each fiscal years 2022 through 2026 for areas of the State with specific populations	Distributed under the Federal-Aid Highway Program ~$52 billion for each FY2022 – 2026	5-year program from FY2022 – FY2026
	Sec. 11115 Congestion mitigation and air quality improvement program	Establishes a program for congestion mitigation and improving air quality. ■ States use appropriated funds for transportation-related projects such as improving shared micromobility, car sharing, replacing, or retrofitting verified technologies, purchasing medium- or heavy-duty zero emission vehicles and related charging equipment to reduce particulate matter. ■ States will prioritize, to the extent of practicability, benefits to disproportionately impacted communities or low-income populations	$13.2 billion distributed over FY2022 – 2026	Effective October 1, 2021
Climate Change	Sec. 11401 Grants for Charging and Fueling Infrastructure	Establish a grant program to increase the accessibility of public electric vehicle charging, hydrogen fueling, propane fueling, and natural gas fueling infrastructure along public alternative fueling corridors or easily accessible public locations for all alternative fuel drivers and to support changes to the transportation sector and reduce greenhouse gas emissions.	$2.5 billion distributed over FY2022 – 2026 Maximum grant amount of $15 million Federal Share: Grants awarded shall not exceed 80 percent of total project cost	The program must be established no later than 1 year after the enactment of the Surface Transportation Reauthorization Act of 2021

		Direct formula funding to States, including the District of Columbia and Puerto Rico, Strategically deploy EV charging infrastructure and establish an interconnected network to facilitate data collection, access, and reliability.	$5.0 billion distributed via formula funding and available until expended.	NEVI Program announced February 10, 2022. States must prepare an EV Infrastructure Deployment Plan before accessing funds – final plans are due by August 1, 2022. FHWA notifies of plan approval, or not, by September 30, 2022.
	Sec. 11403 Carbon reduction program	Amends chapter 1 of title 23, US Code to establish a program to reduce carbon emissions from the transportation sector and appropriate funds to a State to support eligible transportation emission reduction projects.	Distributed under the Federal-Aid Highway Program ~$52 billion for each FY2022 – 2026	The program must be established no later than 2 years after the enactment of the Surface Transportation Reauthorization Act of 2021
Miscellaneous	Sec. 40431 Consideration of measures to promote greater electrification of the transportation sector	Amends section 111 of the Public Utility Regulatory Policies Act of 1978 to add an electric vehicle charging program. Each State shall ■ promote affordable and equitable electric vehicle charging options for residential, commercial, and public charging infrastructure. ■ improve customer experience associated with electric vehicle charging (i.e., reducing charging times for light-, medium-, and heavy-duty vehicles). ■ accelerate third-party investment in light-, medium-, and heavy-duty vehicle charging infrastructure; and recover marginal costs of delivering electricity to electric vehicle charging infrastructure.	N/A	No later than 1 year after enactment, State regulatory and non-regulatory authority shall commence consideration No later than 2 years after enactment, State regulatory and non-regulatory authority shall complete consideration and make the determination under section 111

APPENDIX D POLICY IMPACT ANALYSIS: FURTHER DETAILED RESULTS AND MODELING METHODOLOGY

Supplementing the information provided in Section 7, this appendix provides further detail regarding the modeling analysis results and methodology.

Electricity Requirements and Grid Impacts

Statewide residential and commercial electricity use in Colorado is currently 40 million MWh per year (2020). Annual electricity use is projected to increase to 44 million MWh in 2030 and continue to grow after that, reaching 53 million MWh in 2050 (32 percent greater than 2020 levels). Each scenario is estimated to have its own requirements for electricity consumption and therefore will have different impacts on the grid that will require investments – ZEV charging needs by scenario are estimated to be:

- CO GHG Roadmap: 3.9 million MWh in 2030 and 21.6 million MWh in 2050, an increase of approximately 9 and 41 percent over baseline, respectively.
- ACC II: 3.9 million MWh in 2030 and 27.9 million MWh in 2050, an increase of approximately 9 and 52 percent over baseline, respectively.
- 100 x 50: 5.5 million MWh in 2030 and 28 million MWh in 2050, an increase of approximately 12 and 53 percent over baseline, respectively.

ZEV Charging Load

The timing of the electricity demands discussed above will have a significant impact on the Colorado electric grid demand and investments. This analysis evaluated the effect of ZEV charging on the Colorado electric grid under both a baseline charging scenario as well as a managed charging scenario. Both charging scenarios assume 72 percent of plug-in hybrid electric vehicles (PHEVs) and 82 percent of battery electric vehicles (BEVs) charge exclusively at home and the remaining 28 percent and 18 percent, respectively, charge at locations other than at home (i.e., at work or at other “public” chargers). Baseline charging assumes that drivers begin charging their vehicles immediately upon arrival at home or work. Under the managed charging scenario[47], a significant portion of ZEV owners are assumed to participate in a utility managed charging program, such as a time-of-use rate schedule, to minimize ZEV charging load in the late afternoon and early evening when other electricity demand is high.[48]

Table 10 summarizes the projected incremental afternoon peak hour load (MW) in Colorado, from ZEV charging under each charging and penetration scenario. In general, the projected incremental load is a function of the number of ZEVs on the road and therefore, it is expected that higher load requirements will follow adoption.

[47] Increased peak hour load escalates a utility’s cost of providing electricity and may result in the need to upgrade distribution infrastructure as peak load rises. As such, managed ZEV charging should be used as a method to mitigate these increased costs, which can provide additional net benefits to all utility customers by reducing the cost of providing electricity used to charge ZEVs.

[48] Utilities have many policy options to incentivize managed ZEV charging. This analysis does not compare the efficacy of different options. For this analysis, light-duty managed charging is modeled as 80% of ZEV owners that arrive home between 5 pm and 9 pm delay the start of charging until a designated off-peak period (10 pm and 6 am). This is only one of many managed charging program options that are available to utilities.

Table 10: Projected Incremental Peak Hour ZEV Charging Load

Metric	CO GHG Roadmap		ACC II		100 x 50	
	2030	2050	2030	2050	2030	2050
Baseline ZEV Charging (MW)	1,811	9,355	1,811	12,060	2,551	12,098
Managed ZEV Charging (MW)	1,048	5,411	1,048	6,976	1,476	6,998

Under the CO GHG Roadmap scenario, ZEV charging would add 1,811 MW load during the afternoon peak load period on a typical weekday in 2030. By 2050, the afternoon incremental ZEV charging load would increase to 9,355 MW. By comparison, the afternoon peak hour ZEV charging load in 2030 would be only 1,048 MW for the managed charging scenario, increasing to 5,411 MW in 2050.

For the ACC II scenario, ZEV charging would add 1,811 MW load during the afternoon peak load period in 2030. By 2050, the afternoon incremental ZEV charging load would increase to 12,060 MW. Managed charging could help lessen afternoon peak hour ZEV charging load in 2030 reaching 1,048 MW and increasing to 6,976 MW in 2050. As a result of earlier and more aggressive EV penetrations, the 100 X 50 scenario has much higher medium-term grid load requirements, adding nearly 2,551 MW in 2030 under a baseline charging scenario; this load increases to over 12,000 MW in 2050 when 100 percent of the in-use fleet are ZEVs. Conversely, a managed charging scenario adds 1,476 MW in 2030 and just under 7,000 MW in 2050. Figure 10 provides a graphical comparison of incremental ZEV charging load for the different scenarios.

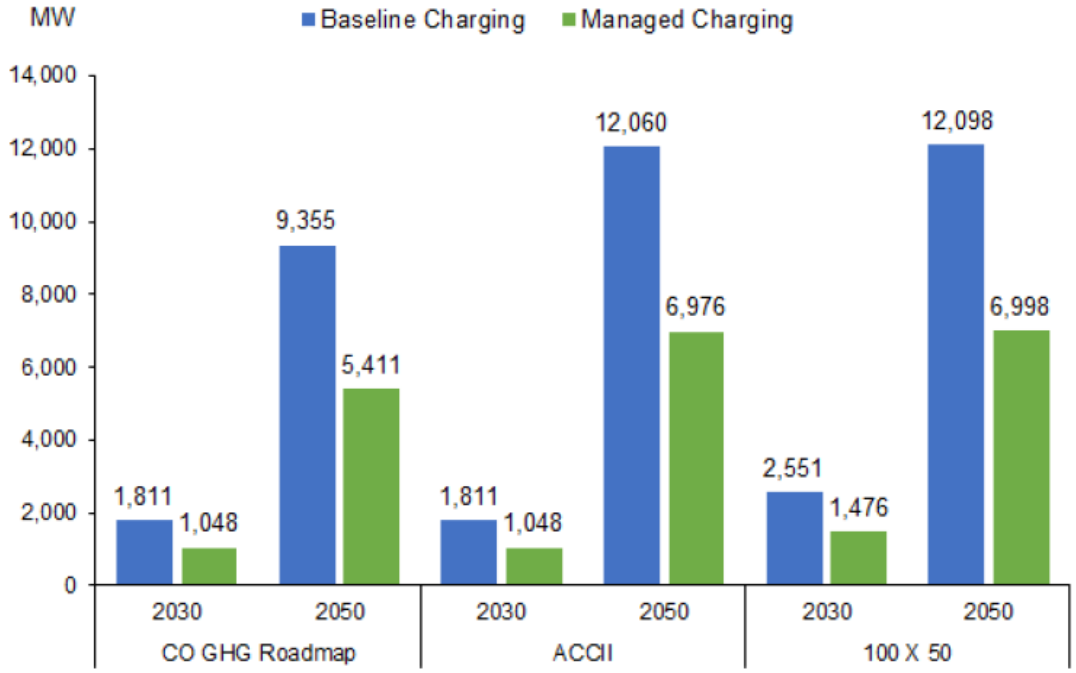


Figure 10: Projected ZEV Charging Load

UTILITY CUSTOMER BENEFITS

Estimates of annual revenues and costs in 2030, 2040, and 2050, resulting from Colorado's electric utilities supplying electricity to charge ZEVs under each scenario, are shown in Figure 11. Projected annual utility revenue is shown in dark blue. The different elements of incremental annual cost that utilities would incur to purchase and deliver additional electricity to support ZEV charging are shown in yellow (generation & transmission), and orange (incremental generation and infrastructure capacity). Generation and transmission costs are proportional to the total power (MWh) used for ZEV charging, while generation capacity costs are proportional to the incremental peak load (MW) imposed by ZEV charging. Infrastructure upgrade costs are costs incurred by the utility to upgrade their distribution infrastructure to handle the increased peak load imposed by ZEV charging.

Revenue resulting from electricity sold for ZEV charging in Colorado for each scenario is estimated to be:

- CO GHG Roadmap: $474 million in 2030 and $2.9 billion in 2050 (2020$).
- ACC II: $422 million in 2030 and $3.5 billion in 2050 (2020$).
- 100 x 50: $666 million in 2030 and $3.5 billion in 2050 (2020$).

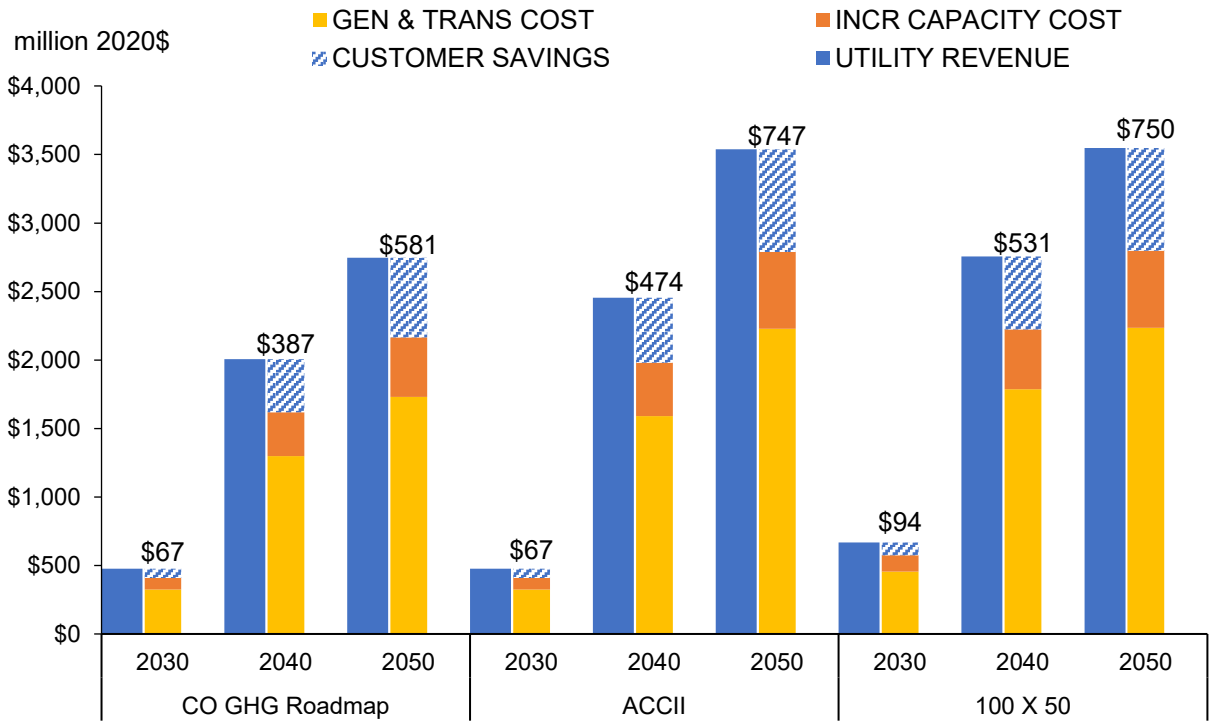


Figure 11: Projected Annual Utility Revenue and Costs from ZEV Charging

In general, utility costs, including distribution infrastructure, are passed on to utility customers in accordance with rules established by the Colorado Public Utilities Commission (PUC), via periodic increases in residential and commercial electric rates. However, under the PUC rules, additional electricity sales generally offset the allowable costs that can be passed on via higher rates. As such, the majority of projected utility net revenue from increased electricity sales for ZEV charging would be expected to be passed on to utility customers in Colorado, not retained by the utility companies.

Customer savings resulting from electricity sold for ZEV charging (Figure 11, striped light-blue line) represent the annual net revenue (revenue minus costs). Customer savings for each scenario is estimated at:

- CO GHG Roadmap: $67 million in 2030 and $581 million in 2050 (2020$).
- ACC II: $67 million in 2030 and $747 million in 2050 (2020$).
- 100 x 50: $94 million in 2030 and $750 million in 2050 (2020$).

Under current rate structures, utility net revenue would in effect put downward pressure on future rates, delaying or reducing future rate increases, thereby reducing electric bills for all residential and commercial customers.

Figure 12 summarizes how the projected utility customer savings from ZEV charging could affect average annual residential and commercial electricity bills for all Colorado electric utility customers.[49] Under the 100 X 50 scenario, projected average electric rates in Colorado could be reduced up to 9 percent in 2050 due to utility customer savings from ZEV charging, resulting in an annual savings of approximately $110 per residential and $745 per commercial utility customer in Colorado (nominal dollars).

It must be noted that utility customer savings from ZEV charging is dependent on the rate structure chosen by ZEV owners. If ZEV owners choose a different rate schedule – to specifically incentivize off-peak ZEV charging – this could shift some or all the utility customer savings benefit to ZEV owners by reducing their electricity costs for vehicle charging without reducing costs for non-ZEV owners. In either case, rate payers who do not own a ZEV will not be negatively impacted, even if they continue to own ICE vehicles.

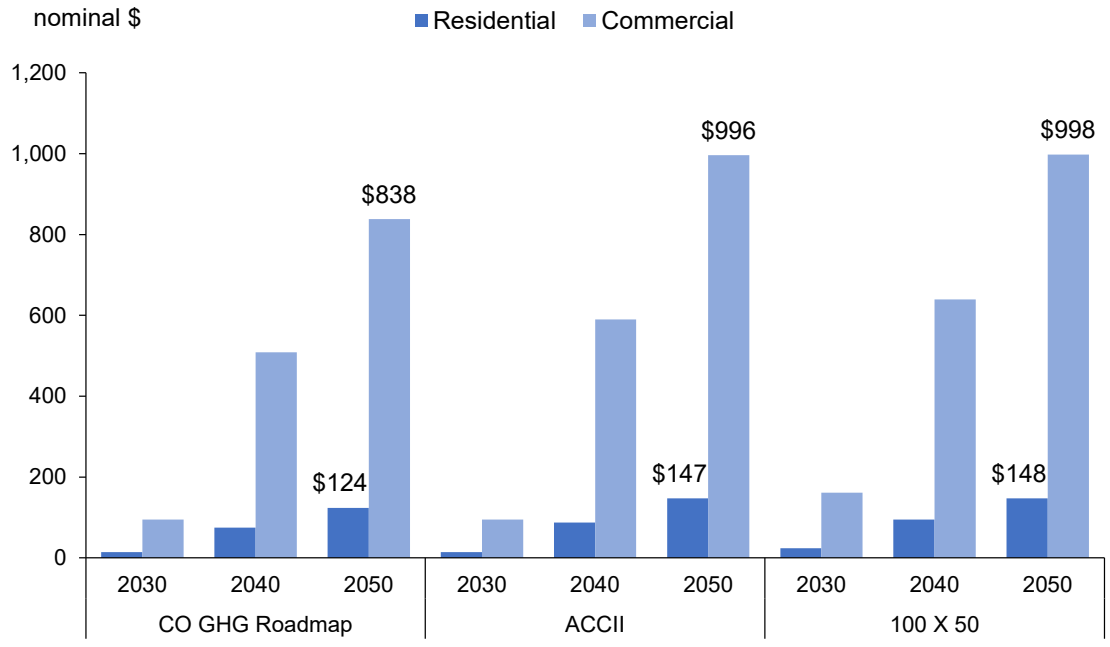


Figure 12: Potential Effect of ZEV Charging Net Revenue on Utility Customer Bills (nominal $)

[49] Based on 2020 residential and commercial average electricity use of 8,187 kWh and 55,391 kWh, respectively per utility customer in Colorado. This does not represent a customer's total bill, but annual savings that could be realized.

COLORADO ZEV OWNER BENEFITS

Current light-duty ZEVs are more expensive to purchase than similar sized gasoline vehicles, but they are eligible for various government purchase incentives, including a federal tax credit of up to $7,500. These incentives are important to spur an early market, but as described below, ZEVs are projected to provide a lower total cost of ownership (TCO) than conventional vehicles in Colorado by about 2025, even without government purchase subsidies.

The largest contributor to incremental purchase costs for ZEVs compared to ICE vehicles is the cost of batteries. In the last eight years, battery costs for plug-in vehicles have fallen from over $1,000/kWh to less than $300/kWh; many analysts and auto companies project that battery prices will continue to fall – to below $100/kWh by 2025, and below $75/kWh by 2030.[cxv]

Based on these battery cost projections, this analysis projects that the lifetime total cost of owning a light-duty ZEV in Colorado will fall below the average cost of owning a gasoline vehicle by 2025, even without government purchase subsidies.[50] However, passenger car initial purchase costs for ZEVs are not projected to reach parity until 2032 for a BEV with 200 miles of range (BEV200), while a BEV with 300 miles (BEV300) is not projected to reach parity with gasoline ICE vehicles until after 2050. For light trucks, purchase cost parity is not reached until 2033 for a BEV200, while a BEV300 does not reach parity until after 2050. PHEVs for both passenger cars and light trucks are not projected to reach parity with ICE vehicles. Figure 30 provides an illustrative example of the lifecycle costs of light-duty Colorado ZEVs for different model year vehicles under the 100 X 50 penetration scenario.[51]

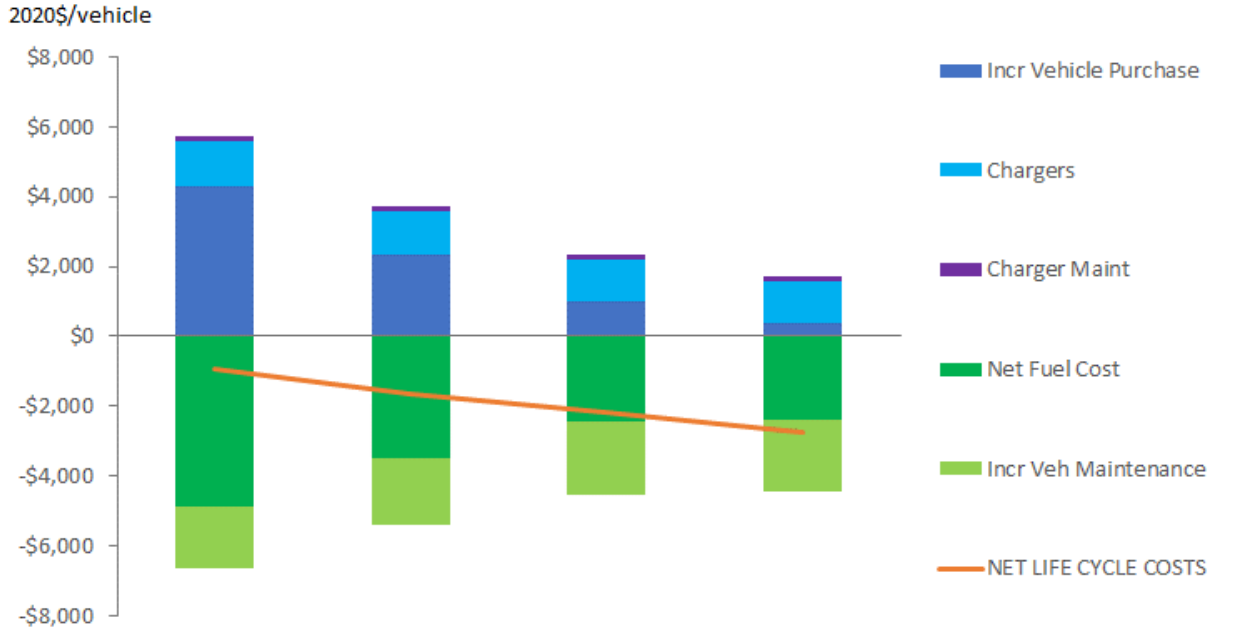


Figure 13: Projected Net Lifecycle Costs per LD ZEV (2020$)

[50] The analysis assumes that all battery electric vehicles in-use after 2030 will either have 200-mile range or 300-mile range per charge and that all plug-in hybrid vehicles will either have 25-mile or 50-mile all-electric range.

[51] Figure 13 columns represent calendar years 2025, 2030, 2040, and 2050 (from left to right).

As shown in Figure 13 under the 100 X 50 Scenario, the estimated average incremental ZEV purchase price for model year 2040 (MY2040) is projected to be positive (higher than average purchase costs for gasoline vehicles with no government subsidies). However, the effect of this incremental purchase cost is outweighed by significant fuel and scheduled maintenance cost savings. Additional costs are also included in this calculation for vehicle chargers and periodic inspections and maintenance of the vehicle charger. The Net Life Cycle Costs (orange line) accounts for all of these costs and benefits to the vehicle owner, calculated over the vehicle's lifetime.[52] The resulting estimated savings for an average Colorado ZEV owner of a MY2025 LD ZEV is projected at just under $1,000 over the vehicle's life due to reduced fuel use and maintenance. This lifetime savings increases to over $2,700 per LD ZEV for MY2040 vehicles.

ENVIRONMENTAL BENEFITS

Fuel, Climate and Air Quality Impacts

Along with the financial benefits to electric utility customers and ZEV owners described above, vehicle electrification can provide additional benefits, including significant reductions in fuel use and transportation sector GHG, NOx and PM emissions.

Fuel Impacts

The estimated cumulative fuel savings (barrels of petroleum fuel[53]) from ZEV use in Colorado under each scenario are shown in Figure 14 and range from a 13 percent savings (2030, ACC II scenario) to 100 percent (2050, 100 x 50 scenario). These fuel savings can help put the U.S. on a path to decarbonization, by reducing the need for petroleum fuel. In addition, a number of studies have demonstrated that EVs can generate significantly greater local economic impact than ICE vehicles – including generating additional local jobs - by keeping more of vehicle owners' money in the local economy rather than sending it out of state by purchasing petroleum fuels.[cxvi,cxvii,cxviii]

[52] For this analysis, LDVs are assumed to have a 16-year lifetime. These values are consistent with historical vehicle registration data published by the Federal Highway Administration as part of their Transportation Energy Data Book series (2020). Fuel and maintenance savings have been discounted at a rate of 6% for comparison to incremental purchase costs.

[53] One barrel equals 42 US gallons; petroleum fuel includes gasoline and diesel fuel.

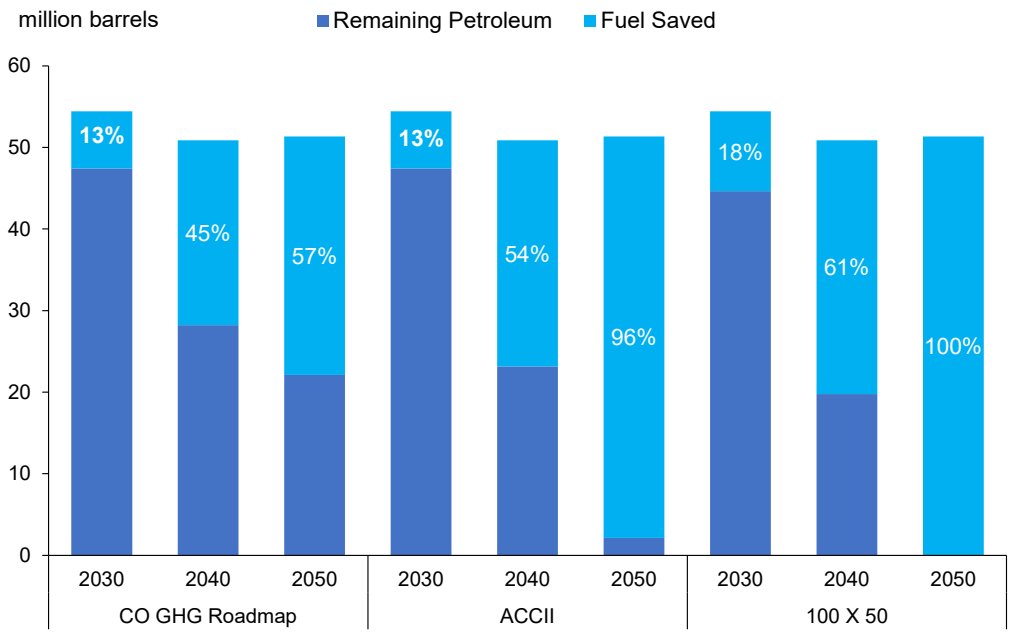


Figure 14: Projected Fuel Savings from ZEVs

Climate Impacts

The projected annual GHG emissions (million metric tons carbon-dioxide equivalent, MMT CO_2-e) from the Colorado fleet under each ZEV penetration scenario are shown in Figure 15. The figure also illustrates a "baseline" trajectory (gray line), in which the Colorado fleet maintains its current mix of gasoline vehicles and their associated emissions. Reductions associated with each ZEV scenario are compared against this baseline.

In this figure, projected emissions under the ZEV scenarios represent "well-to-wheels" (WTW) or "lifecycle" emissions, including direct tailpipe emissions and "upstream" emissions from production and transport of fuels. Estimated emissions for the ZEV scenarios include GHG emissions from generating electricity to charge ZEVs, as well as GHG emissions from gasoline, diesel, and natural gas vehicles in the fleet. Estimated emissions from ZEV charging along with upstream emissions for gasoline, diesel fuel and natural gas are based on Argonne National Laboratory's Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) Model outputs. Tailpipe emissions were calculated using EPA's Motor Vehicle Emission Simulator (MOVES) model.

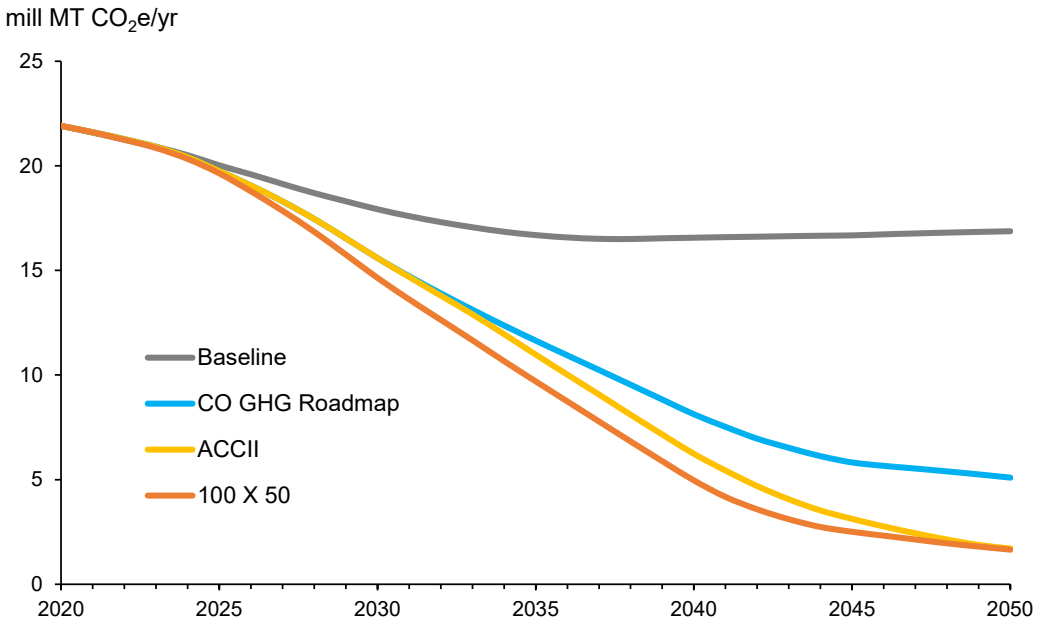


Figure 15: Projected GHG Emissions from the Light-Duty Fleet

As shown in Figure 15, GHG emissions from light-duty vehicles in Colorado were approximately 21.9 MMT in 2020. Under the baseline trajectory, emissions are projected to fall to 16.9 MMT by 2050 due to turnover in the fleet to more efficient ICE vehicles.

Compared to baseline emissions in 2050, annual GHG emissions are projected to be reduced by up to 11.8 MMT under the CO GHG Roadmap ZEV penetration scenario and 15.2 MMT under the ACC II and 100 X 50 scenarios.

Table 11 summarizes the projected monetized "social value" of cumulative GHG reductions (2020-2050) that will result from greater ZEV use in Colorado. The social value of GHG reductions represents potential cost savings from avoiding the negative effects of climate change, if GHG emissions are reduced enough to keep long-term warming below two degrees Celsius from pre-industrial levels. The values summarized in Table 11 were developed using the Social Cost of CO_2 (2020$/MT) as calculated by the U.S. government's Interagency Working Group on Social Cost of Greenhouse Gases.

Table 11: Cumulative GHG Emissions and Monetized Value by Scenario

Scenario	Cumulative Reductions – 2050 (MMT CO_2-e) [A]	Monetized Value (2020$, billion) [B]
CO GHG Roadmap	176.7	$18.9
ACC II	214.9	$23.0
100 X 50	241.3	$25.7

[A] Compared against baseline trajectory
[B] See Table 14 for the social cost of GHG values used to derive these monetized values.

Air Quality Impacts

Figures 16 and 17 show estimated annual well-to-wheels[54] NOx and PM emissions, respectively, under the baseline scenario compared against the CO GHG Roadmap, ACC II, and 100 X 50 ZEV scenarios. Under the baseline scenario, assuming no change to current policies, annual NOx emissions from Colorado vehicles are projected to fall by 66 percent and annual fleet PM emissions are projected to fall by 21 percent through 2045 and 2038, respectively, as the current fleet turns over to newer gasoline cars and light trucks that meet more stringent EPA emissions standards.[55] In later years, baseline annual NOx and PM emissions are then projected to start rising again as annual fleet VMT continues to grow.

Compared with the baseline, the CO GHG Roadmap scenario is estimated to decrease annual vehicle NOx by 88 percent, while PM emissions are projected to decrease by 54 percent in 2050.

Under the ACC II scenario, estimated annual fleet NOx is projected to decline 94 percent by 2050 as increasing levels of gasoline vehicles are replaced with ZEVs faster than ICE vehicles turnover. PM emissions are projected to decrease by 61 percent due to the Colorado electric grid decarbonizing faster than the ICE fleet can turn over to cleaner vehicles.

The 100 X 50 scenario has the lowest vehicle NOx emissions due to replacing all gasoline vehicles with ZEVs by 2050, when annual NOx and PM emissions are estimated to be 95 percent and 67 percent lower, respectively, than baseline emissions by 2050.

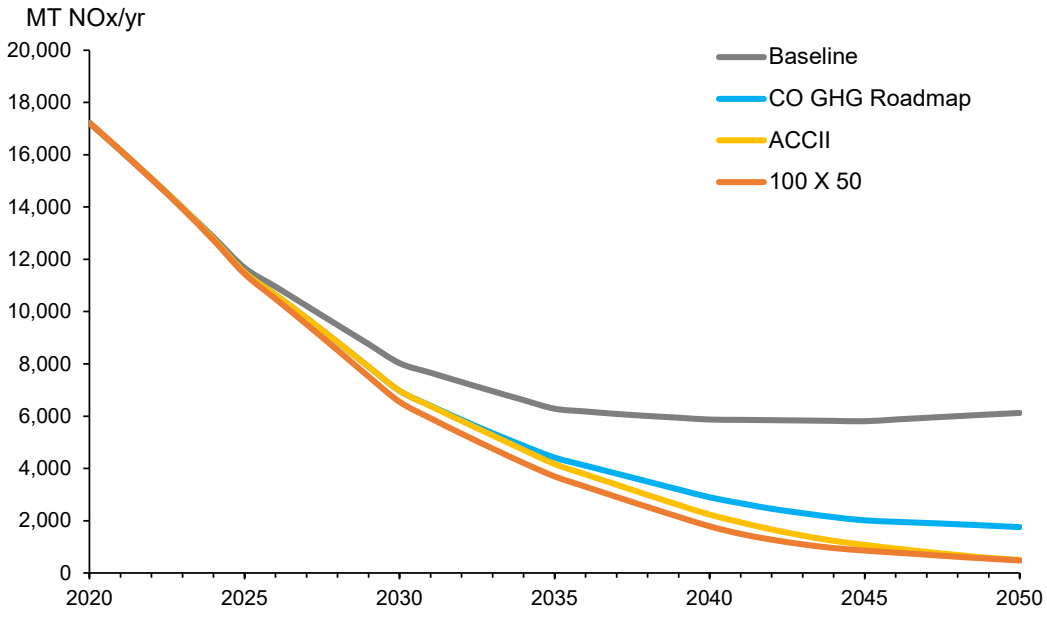


Figure 16: Projected Light-Duty Fleet NOx Emissions

[54] NOx and PM emissions include “upstream” emissions from production, processing, and distribution of fuels as well as tailpipe emissions from vehicles.

[55] 2045 and 2038 represent the ‘low point’ on the curve for the baseline scenario for NOx and PM, respectively.

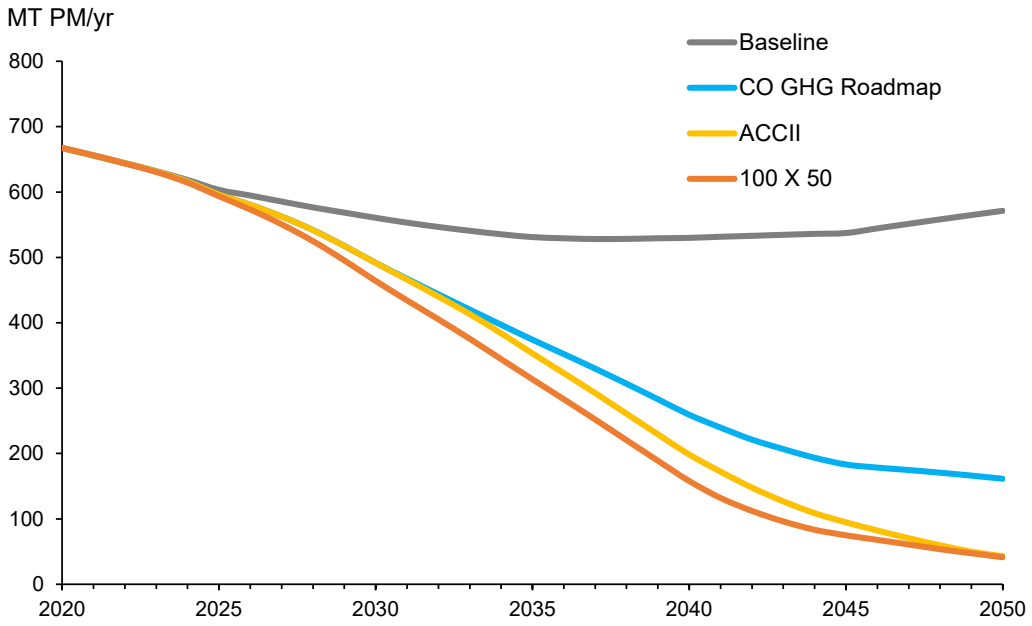


Figure 17: Projected Light-Duty Fleet PM Emissions

The reduced annual air quality emissions discussed above could reduce negative health effects on Colorado residents from breathing in these pollutants. Estimated public health impacts include reductions in premature mortality, fewer hospital admissions and emergency room visits for asthma. There will also be reduced cases of acute bronchitis, exacerbated asthma, and other respiratory symptoms, and fewer restricted activity days and lost workdays. Cumulative estimated reductions in these health outcomes in Colorado under the modeled ZEV scenarios are shown in Table 12. These benefits were estimated using the U.S. Environmental Protection Agency's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool.

Table 12: Cumulative Public Health Benefits of ZEV Scenarios (2020-2050)

Health Metric	CO GHG Roadmap	ACC II	100 X 50
Avoided Premature Deaths	231	281	310
Avoided Hospital Visits [A]	221	268	296
Avoided Minor Cases [B]	145,719	177,315	195,677
Monetized Value, 2020$ (billions)	$2.7	$3.3	$3.6

[A] Hospital visits include hospital admissions plus emergency room visits.
[B] Includes reduced cases of acute bronchitis and other respiratory symptoms and reduced restricted activity days and lost workdays.

The monetized value of cumulative public health benefits from the CO GHG Roadmap scenario over the next 30 years totals more than $2.8 billion. For the ACC II scenario, the monetized value of cumulative net public health benefits would be nearly $3.2 billion, while under the 100 X 50 scenario, cumulative public health benefits total $3.6 billion through 2050.

TOTAL SOCIETAL BENEFITS

The total annual estimated benefits from increased ZEV use in Colorado under each ZEV penetration scenario are summarized in Figure 18. These benefits include cost savings to utility customers from reduced electric bills, Colorado ZEV owners' savings, climate benefits from reduced fossil fuel usage as well as monetized air quality benefits.

Of particular note for 2030, the ZEV owner savings are estimated to be negative (i.e., a net cost generally attributable to EVs not having achieved cost parity yet) and when combined with the other positive societal benefits yields a net cost of $0.03 billion. These benefits rise by 2040, reaching a minimum of $2.4 billion per year under the CO GHG Roadmap ZEV penetration scenario and $2.8 billion under the ACC II scenario. In 2050, the CO GHG Roadmap scenario projects $3.6 billion in annual societal benefits, while the ACC II scenario provides nearly $4.6 billion in annual societal benefits. For the 100 X 50 ZEV scenario, annual societal benefits are projected to be $3.3 billion in 2040 and $4.6 billion in 2050.

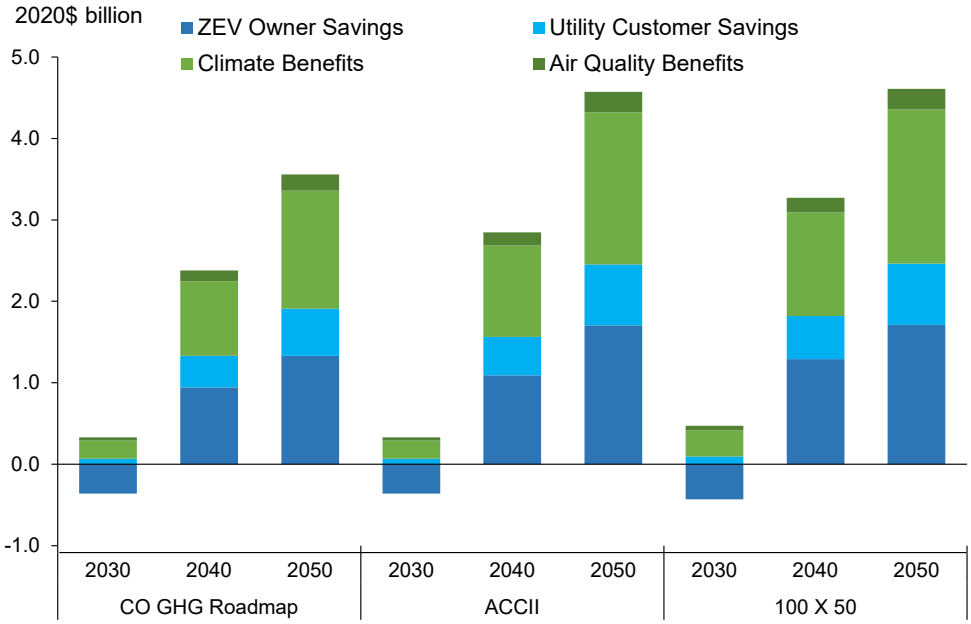


Figure 18: Projected Total Societal Benefits by Scenario

ANALYSIS METHODOLOGY

This study evaluated the costs and benefits of three distinct levels of ZEV penetration in Colorado between 2020 and 2050, based on publicly available ZEV adoption estimates from various analysts.

- CO GHG Roadmap ZEV Scenario: The scenario is based on Colorado's GHG Roadmap goal of 940,000 in-use ZEVs by 2030. After 2030, the sales trajectory is assumed to continue its trend through 2050. Under this scenario approximately 86 percent of in-use light-duty vehicles in Colorado will be ZEV in 2050.

- ACC II ZEV Scenario: Assumes Colorado adopts the proposed California Advanced Clean Cars II (ACC II) rule – Fall 2021 version – mandating sales of ZEVs after 2026, resulting in 100 percent of sales by 2035. After 2035, all light-duty vehicle sales are assumed to be ZEV. This scenario results in nearly 100 percent of in-use light-duty vehicles in 2050 being ZEV.
    - This scenario is not expected to have additional cost burdens on Colorado taxpayers as the ACC II rule is a requirement for manufacturers. Although this may be reflected in consumer cost (e.g., sticker price), this scenario does not contemplate any additional financial incentives from the State than what is currently available. However, it is likely that Colorado would need to continue investments in infrastructure and other supporting measures if adopting ACC II.
- 100 X 50 ZEV Scenario: Assumes the same sales trajectories as the CO GHG Roadmap scenario through calendar year 2025, and then presumes that CO enacts additional legislation to reach 100 percent of light-duty vehicles being ZEV by 2050:
    - Transportation Network Company Requirement – Assumes Colorado adopts California's Clean Miles Standard, requiring 90 percent of Transportation Network Company (TNC) mileage to be "clean" after 2030. Results in less than 1 percent of additional ZEV sales annually (2030-2050)
    - Light-Duty Vehicle Replacement Program – Colorado implements an incentive program to replace vehicles older than 10 years for a new ZEV from 2026 through 2033.
        - The timeframe is assumed to begin immediately after the current Zero Emission Vehicle Tax Credits (Income 69) program sunsets at the end of 2025.
        - Results in an incremental increase of 11.2 percent of passenger cars and 14 percent of light truck sales being ZEV (2026-2033).
        - The incentive assumes passenger cars will receive $5,000 and light trucks $8,500 and between 2026 and 2033 will result in the replacement of a combined 274,555 vehicles at a projected cost of $1.64 billion.
    - Light-Duty EV Incentive Program – Colorado begins a new incentive (could be tax credit, dealer incentives, feebates) for ZEV purchases starting in 2026 when the current State tax credits phase out and running through 2037. The incentive is assumed to increase ZEV sales 10 percent over baseline sales assumptions, providing a 11.5 percent annual ZEV sales contribution by 2037.[cxix]
        - The incentive assumes a purchaser (whether via tax rebate, incentive or feebate) will receive $2,000 – which aligns with current program design – and result in an estimated cost of $467 million over the life of the program.
    - Light-Duty Fleet Rule – In this hypothetical policy, light-duty fleets larger than 90 vehicles would be required to meet a 100 percent ZEV sales mandate by 2030. A very preliminary analysis by the Colorado Department of Public Health and Environment indicates that approximately 65,000 vehicles spread across 77 fleets would be subject to the rule (for LDV fleets with >90 vehicles). Fleets are assumed to maximize the time period for transition and that there are currently no EVs in the fleet. Fleet purchases are assumed to be 2.5 percent of vehicle sales during the time period of 2022-2030.

These scenarios are compared to a baseline scenario with little ZEV penetration and continued use of gasoline vehicles. The baseline scenario is based on future annual vehicle miles traveled (VMT) and fleet

characteristics (e.g., cars versus light trucks) as projected by the Energy Information Administration in their most recent Annual Energy Outlook (AEO 2021).[56]

ZEV characteristics, such as the split of vehicle sales (BEVs versus PHEVs) is assumed to change over time, as projected vehicle costs for BEVs decline due to technology advances. See Figure 19 for a projected split of BEV vs PHEVs among new vehicle sales for each year identified by range of each vehicle (e.g., PHEV50 is a plug-in hybrid with 50 miles of all electric range)

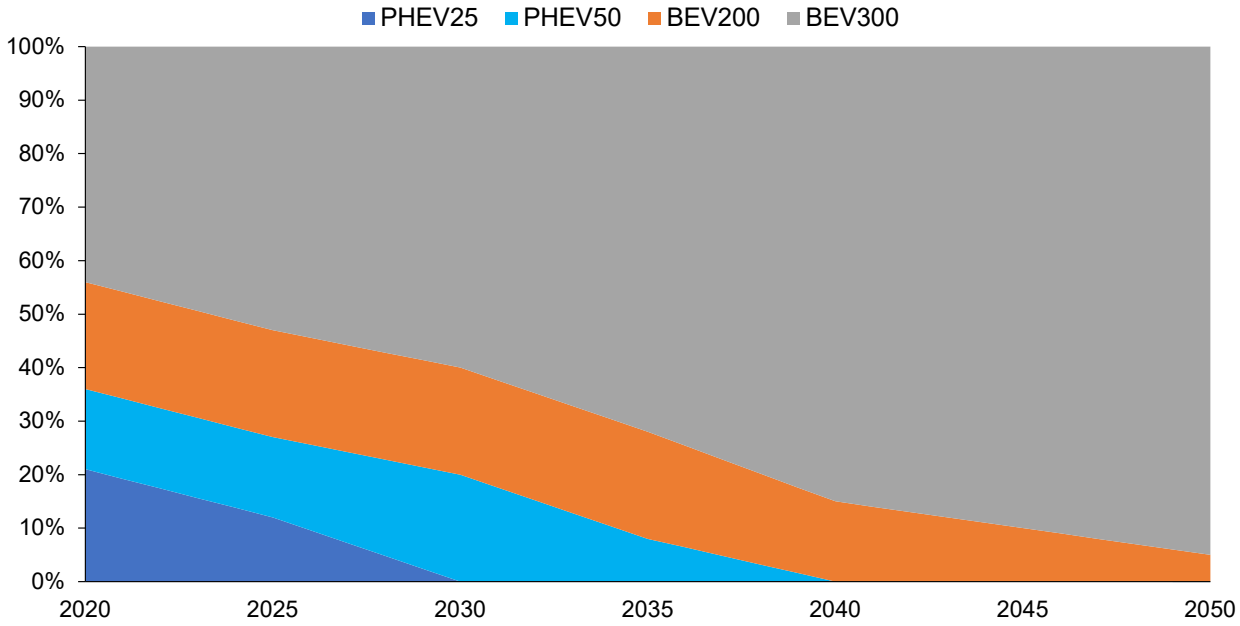


Figure 19: Projected Split of EV vs. PHEV – New Vehicle Sales

Scope of the Modeling Framework

The modeling framework encompasses five interconnected analyses that together estimate the climate, air quality/health, and economic impacts of each ZEV policy scenario relative to the baseline scenario. These analyses are summarized in Table 13. Climate and air quality impacts are estimated based on changes in fleet fuel use and include both tailpipe emissions and "upstream" emissions from production of the transportation fuels used in each scenario. This includes the petroleum fuels (gasoline, diesel, and natural gas) used by conventional ICE vehicles and the electricity used by ZEVs, which are assumed to include both BEV and PHEV.

[56] Tables 7, 38.8 (Mountain Region) and 41

Table 13: Modeling Framework

Analysis	Framework Elements
Fuel Use & Emissions	Change in fuel use (diesel, gasoline, electricity)
	Change in emissions: GHG (CO_2, CH_4, N_2O) and criteria pollutants (NOx, PM)
	WTW (tailpipe and upstream emissions)
	Monetized value of net emission reductions
Health Impacts	Change in premature deaths due to lower NOx and PM emissions
	Change in hospital visits & lost workdays due to lower NOx and PM emissions
	Monetized value of net health benefits
Economic	Change in spending on vehicle purchase, fuel, and maintenance
	Charging infrastructure investments
Utility Impacts	Change in electricity use and load
	Utility net revenue
	Impact on electricity rates
Gap	Estimate state-level charging infrastructure needs

To evaluate climate impacts, the analysis estimates changes in all combustion-related GHGs, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). To evaluate air quality impacts, the analysis estimates changes in NOx and PM emissions and resulting changes in health metrics such as premature deaths, hospital visits, and lost workdays.

The economic analysis estimates the change in annual fleet-wide spending on vehicle purchase, charging/fueling infrastructure to support ZEVs, vehicle fuel, and vehicle and infrastructure maintenance. Currently ZEVs are more expensive to purchase than equivalent gasoline and diesel vehicles, but they have lower fuel and maintenance costs. Over time the incremental purchase cost of ZEVs is also projected to fall.

The utility impacts analysis assesses the total statewide change in electricity load (kW) and usage (kWh) for EV charging, as well as the additional revenue and net revenue that would be received by the State's electric utilities for providing this power.[57] Based on projected utility net revenue, the analysis estimates the potential effect on state electricity rates for residential and commercial customers.

[57] Utility net revenue is revenue minus the costs of procuring the necessary bulk electricity.

The infrastructure gap analysis estimates the total number of vehicle chargers—home and depot-based chargers as well as shared "public" ones—that will be required to support the increase in EVs under each scenario compared with the existing charging network in the state.

Methodologies and Assumptions

This section discusses the methodologies and major assumptions used in each section of the modeling framework. All dollar values presented are constant 2020$, unless otherwise noted.

Fuel Use and Emissions Analysis

The modeling framework uses ERM's STate Emission Pathways (STEP) Tool to generate, for each year through 2050, total fuel/energy use by the vehicle fleet at the state level under each modeled scenario. Fuel use is disaggregated by vehicle type (passenger car and light truck) and by fuel type (gasoline, diesel, natural gas, electricity) based on the modeled changes in fleet composition under each scenario. These annual projections are then used as inputs to the emissions analysis and the economic analysis.

The STEP Tool is a spreadsheet-based multi-sector model that allows users to analyze state and regional energy use and their CO_2 emission trajectories under a range of economy-wide policy scenarios. It lets users build detailed custom policy scenarios by selecting from various policy options in each sector of the economy—electric, transportation, residential, commercial, and industrial—while tracking in real time the associated overall electricity generation, portfolio mix, total energy use by fuel type, and vehicle miles traveled by type. The inclusion of multiple sectors of the economy allows users of the STEP Tool to examine certain energy-use interactions among the different sectors of the economy (e.g., the impact of electric vehicles on both the electric and transportation sectors).

To produce scenario projections quickly and efficiently, the STEP Tool uses a non-optimization approach to solve for and calculate future energy use and CO_2 emissions. It does not try to reach any equilibrium condition or optimize the system for any variables. Instead, it records each user selection to construct one or more policy scenarios and then calculates their impacts in terms of changes to existing patterns of energy use. It makes use of heuristics and simplifying assumptions to produce projections at an indicative level. STEP Tool outputs can be generated for the entire U.S. economy or for individual states or groups of states.

The STEP Tool relies, for the most part, on publicly available data sets from federal and state-level government agencies to build up detailed characterizations of historic energy use patterns for each sector of the economy. For example, for the transportation sector, the focus of this modeling framework, the STEP Tool uses the Federal Highway Administration's (FHWA) "Highway Statistics" publication as the starting point for the development of Colorado data on vehicle miles traveled, size of current vehicle stocks by vehicle type, and so on. For this modeling framework the STEP Tool was updated to the latest data sets available at the time the analysis was conducted, including FHWA 2019 fleet data[cxx], and EIA's Annual Energy Outlook 2021[cxxi].

The STEP Tool incorporates the variability in vehicle stock and future VMT growth embedded in the FHWA and EIA data sets, which will affect the outcomes of analyzed policy scenarios. The STEP tool also incorporates assumed future improvements in fleet average vehicle fuel economy (mpg) as the fleet turns over to new conventional ICE vehicles compliant with current EPA new vehicle and engine fuel economy and GHG emission standards. These improvements are reflected in the baseline scenario, and all analyzed policy scenarios.

Shown in Figure 20 under the CO GHG Roadmap scenario, VMT from ZEVs in Colorado would increase to 10.1 billion miles in 2030 (17 percent of total VMT), 43.2 billion in 2040 (63 percent of total), and 65 billion in 2050 (82 percent of total). Under the ACC II scenario VMT from ZEVs increases to over 9.0 billion miles in Colorado by 2030 (15 percent of total), rising to 48.3 billion in 2040 (71 percent of total),

and 76.3 billion in 2050 (97 percent of total). Looking at the 100 X 50 scenario, ZEVs are projected to drive 13.7 billion miles in Colorado by 2030 (23 percent of total), rising to 55.3 billion in 2040 (81 percent of total), and 75.6 billion in 2050 (100 percent of total).

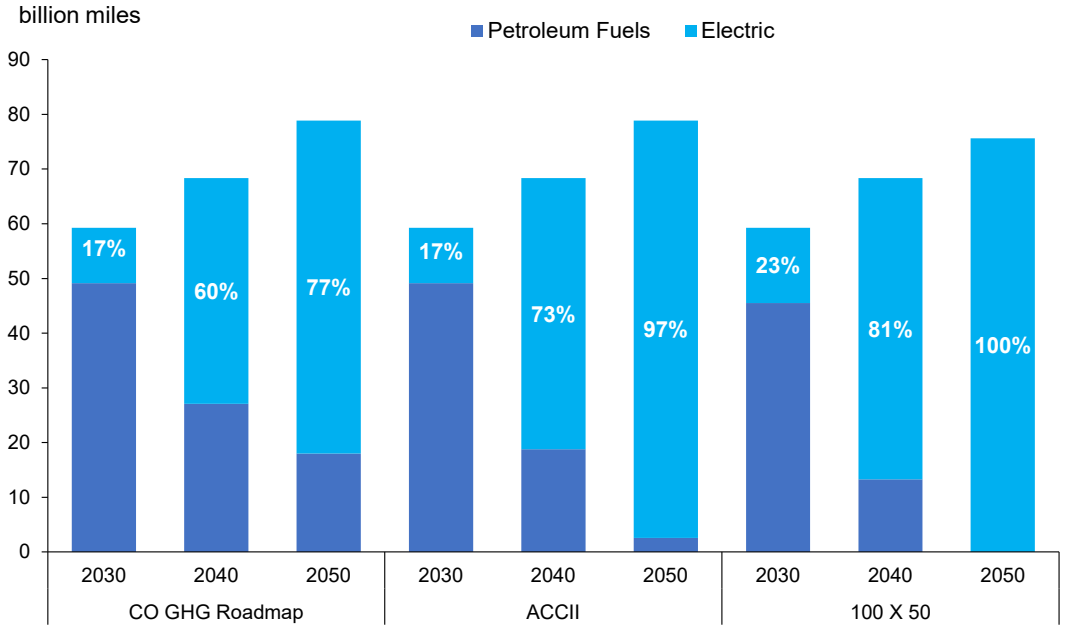


Figure 20: Projected Colorado Light-Duty Fleet VMT

For each policy scenario, annual net reductions in GHG emissions compared with the baseline are estimated based on modeled changes in fuel use (gasoline, diesel, natural gas, and electricity). Calculated GHG emissions include CO_2, CH_4, and N_2O, with the latter two expressed in carbon dioxide–equivalent terms (CO_2-e) using their global warming potential over a 100-year period (GWP100 = 25 for CH_4 and 298 for N_2O), as estimated by the United Nations Intergovernmental Panel on Climate Change's Fifth Assessment Report.[cxxii]

Estimated GHG, NOx, and PM emissions include tailpipe emissions from gasoline and diesel vehicles and upstream emissions from production and delivery of the different fuels, including from generation of electricity to charge EVs.[58]

Tailpipe emission factors for gasoline and diesel vehicles (g/gallon) were derived from the latest version of EPA's MOtor Vehicle Emission Simulator (MOVES3) model[cxxiii] by mapping STEP Tool vehicle types to vehicle types in MOVES.

Upstream emission factors (g/gallon for diesel and gasoline, g/kWh for electricity) were developed using the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) Model developed by Argonne National Laboratory.[cxxiv]

For electricity, the framework uses weighted average GHG, NOx and PM emission factors (g CO_2/kWh, g CH_4/kWh, g N_2O/kWh) that were developed using GREET emission factors for coal, natural gas combined cycle (NGCC), and zero-emitting electricity generation, and Colorado-specific assumptions for the percentage of generation from each of these sources each year. For each scenario, emissions from ZEV

[58] Brake and tire wear PM emissions have not been included in this analysis.

charging are calculated based on a “Low carbon electricity” scenario. The low carbon electricity assumption is based on Colorado achieving 68 percent renewable energy by 2030 and 94 percent carbon-free electricity generation by 2050, similar to the assumptions for the 2019 Action Scenario in the GHG Roadmap.

Annual net reductions in emissions of NOx and PM relative to the baseline are estimated based on modeled changes in fuel use (gasoline, diesel, natural gas, electricity, and hydrogen) for each ZEV policy scenario.

The monetized “social value” of these GHG reductions from ZEV use are calculated using the Social Cost of GHG ($/MT), as well as social costs for CH_4 and N_2O gases.[59] The Social Cost of GHG is a measure of monetized future damages resulting from the increase of carbon dioxide emissions and is expressed as current dollars per metric ton of pollutant. These monetary damages include (but are not limited to): flood-related property damage, decreased agricultural crop production, reduced human health, and loss of climate-change-related ecosystem services. The Federal government created the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), which is tasked with maintaining current social costs of pollutants. The IWG operated from 2009-2017, before being disbanded by the Trump Administration. When the Biden administration took office in 2021, the IWG was reconvened and continues to maintain current estimates of social costs.

To calculate the monetized value of the net GHG reductions in each ZEV policy scenario (relative to the baseline scenario) the framework uses values for the Social Cost of Greenhouse Gases (CO_2, CH_4, and N_2O) that were developed by the U.S. government’s Interagency Working Group.[cxxv] The Interagency Working Group published social cost estimates based on average modeling results using 2.5 percent, 3 percent, and 5 percent discount rates, as well as 95th percentile results using a 3 percent discount rate. This framework uses the average values resulting from a 2.5 percent discount rate, consistent with Colorado State legislation.

NOx and PM emission reductions for ZEV use are also monetized for this analysis and are based on EPA’s CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). See Table 14 for a summary of the monetized air quality avoided cost assumptions along with the social values for GHGs.

[59] Consistent with Colorado State legislation, this analysis uses values from the Interagency Working Group on Social Cost of Greenhouse Gases, “Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis” August 2016 (CO_2) and “Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide, August 2016 (CH_4 and N_2O).

Table 14: Monetized Benefits of GHGs, NOx and PM

2020 $/MT			2020	2030	2040	2050
GHG	CO_2	2.5 Percent Discount Rate	$76	$90	$103	$117
	CH_4		$1,966	$2,457	$3,194	$3,808
	N_2O		$27,026	$33,168	$39,310	$45,452
NOx	Vehicle Tailpipe		$9,035	$10,261	$11,474	$12,700
	Electricity Generation		$3,394	$3,854	$4,310	$4,770
	Petroleum Fuel Production		$13,766	$14,690	$15,452	$16,089
PM	Vehicle Tailpipe		$228,585	$259,583	$290,287	$321,303
	Electricity Generation		$75,925	$86,222	$96,420	$106,722
	Petroleum Fuel Production		$237,674	$253,636	$266,779	$277,777

Health Impacts Analysis

To estimate the monetized value of health benefits resulting from reduced NOx and PM emissions, ERM used EPA's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool.[cxxvi] For a given change in annual PM and/or NOx emissions (MT) within a given geography, COBRA estimates the resulting change in ambient PM concentration and the resulting public health impacts. Estimated public health impacts include changes in premature mortality, hospital admissions and emergency room visits for asthma, reduced cases of acute bronchitis, exacerbated asthma and other respiratory symptoms, and reduced activity days and lost workdays. COBRA also estimates the total monetized value of these health impacts ($/MT). Analysis assumptions are presented in Table 15.

While the majority of modeled emission changes from vehicle use and electricity generation are local to Colorado, the same is not true for upstream emissions from producing petroleum fuels. The majority of these emissions occur from production of crude oil and natural gas and from the refining of crude oil to gasoline and diesel fuel. Most of the health benefits estimated by the framework will accrue to residents of Colorado, but those associated with reduced petroleum fuel production will accrue to residents of other states. Moreover, there are additional health benefits (not captured by the modeling) that will accrue to residents of adjacent states from ZEV miles driven in these states.

The framework calculates the health impacts of modeled emission changes from the three different sources separately and sums the results to estimate net effects (reduced tailpipe and upstream petroleum production emissions and increased emissions from electricity generation).

Also note that the magnitude of health effects (incidents/MT, $/MT) will vary primarily according to relative population density; in more densely populated locations more people will be exposed to a given quantity of emissions, resulting in greater total health impacts. The framework uses COBRA health impact values specific to Colorado.

Table 15: Annual Health Impacts of NOx and PM Emissions – Colorado

			NOx		PM	
			2020	2050	2020	2050
Highway Vehicles	Premature Deaths	Incidents/1,000 MT	0.8	1.1	19.5	27.4
	Hospital Admissions	Incidents/1,000 MT	0.5	0.7	12.0	16.9
	Emergency Room Visits	Incidents/1,000 MT	0.3	0.4	7.7	10.8
	Minor Cases	Incidents/1,000 MT	588	826	15,276	21,472
	Monetized Value	2020$/MT	$9,035	$12,700	$228,585	$321,303
Fuel Combustion, Electric Utilities	Premature Deaths	Incidents/1,000 MT	0.3	0.4	6.5	9.1
	Hospital Admissions	Incidents/1,000 MT	0.2	0.2	4.4	6.1
	Emergency Room Visits	Incidents/1,000 MT	0.1	0.1	2.5	3.6
	Minor Cases	Incidents/1,000 MT	211	296	4,843	6,808
	Monetized Value	2020$/MT	$3,394	$4,770	$75,925	$106,722
Fuel Combustion, Petroleum Fuels	Premature Deaths	Incidents/1,000 MT	1.2	1.4	20.3	23.8
	Hospital Admissions	Incidents/1,000 MT	0.7	0.9	12.1	14.2
	Emergency Room Visits	Incidents/1,000 MT	0.4	0.4	6.7	7.9
	Minor Cases	Incidents/1,000 MT	642	751	11,889	13,895
	Monetized Value	2020$/MT	$13,766	$16,089	$237,764	$277,777

COBRA estimates health impacts from changes in ambient PM concentrations, due to PM emitted directly from combustion sources and “secondary” PM generated via chemical reactions in the atmosphere from combustion gases, including NOx. In many locations, changes in NOx emissions also affect the formation of ground-level ozone, particularly in the summer. Ground-level ozone also has negative effects on human health. The potential ozone-related health benefits from net reductions in NOx emissions under the modeled policy scenarios are not captured by the modeling framework; therefore, the estimated net health benefits of the modeled policy scenarios are considered to be a conservative estimate.

Economic Analysis

Increased purchase of zero-emission vehicles under the modeled policy scenarios will have a significant impact on annual operating costs for vehicle owners. Current ZEVs are more expensive to purchase than "baseline" gasoline and diesel vehicles and require purchase and installation of electric vehicle charging infrastructure; in addition to the up-front purchase cost, this infrastructure has ongoing annual maintenance costs.

Alternatively, electricity is less expensive than gasoline and diesel fuel, so ZEVs will have lower annual fuel costs than baseline ICE vehicles. ZEVs are also projected to have lower lifetime maintenance costs than the diesel and gasoline vehicles they replace.[60]

Real world experience from the EV Project demonstrates that, without a "nudge", drivers will generally plug in and start charging immediately upon arriving home after work, exacerbating system-wide evening peak demand.[61] However, if given a "nudge" - in the form of a properly designed and marketed financial incentive - many drivers will choose to delay the start of charging until later times, thus reducing the effect of ZEV charging on evening peak electricity demand.[cxxvii]

Fuel Costs

Net incremental fuel costs for each modeled policy scenario were calculated for each year using estimated changes in total motor gasoline, diesel fuel, and electricity calculated by the STEP tool, and projected annual energy prices. For diesel fuel and gasoline, regional average projected prices from the EIA's Annual Energy Outlook 2021 were used. EIA projects that the average price of gasoline nationally will increase from $2.26/gallon in 2020 to $3.23/gallon in 2050, and that the average price of diesel fuel will increase from $2.52/gallon to $3.69/gallon (2020$). Projected regional prices vary slightly from the national average but have a similar trajectory over time.

This analysis framework assumes that ZEVs will be charged at residential homes as well as public locations (either workplaces or commercial charging locations). An average 2019 rate for residential and commercial customers ($/kWh) was calculated on the basis of total sales to (MWh) and total revenue from customers reported to the EIA by utilities in Colorado.[cxxviii] For electricity costs in future years, the analysis assumes the same year-to-year percentage change as EIA's estimate of future average regional commercial electricity rates.[cxxix] EIA estimates that, unlike diesel and gasoline, electricity rates will fall over time in the Mountain region (in 2020$), resulting in average costs in 2050 that are 16 percent lower than in 2020. The analysis framework does not directly use EIA AEO estimates for regional electricity rates, because they mask potentially significant differences in rates for different states in the same region.

Commercial customers typically pay both an energy charge ($/kWh) and a demand charge ($/kW-month). A charging analysis indicates that in locations with relatively high demand charges, some EV charging could incur average electricity costs ($/kWh) as much as 10 percent higher than average costs for a typical commercial customer, due to slightly higher monthly peak demand (kW) relative to monthly usage (kWh). At the same time, the analysis indicates that the marginal cost for utilities to serve EV charging load will always be lower than the marginal revenue utilities receive. Given this, the framework implicitly assumes that over time, as charging demand increases, commercial rate structures will evolve to more equitably distribute actual demand costs, such that average electricity costs for EV charging will match average costs for other commercial uses.

[60] For example, ZEVs do not require engine oil changes and will likely have less brake wear due to regenerative braking.

[61] The EV Project is a public/private partnership partially funded by the Department of Energy which has collected and analyzed operating and charging data from more than 8,300 enrolled plug-in electric vehicles and approximately 12,000 public and residential charging stations over a two-year period.

Vehicle Purchase and Maintenance Costs

Incremental purchase costs and incremental maintenance costs for LD EVs were estimated using California Air Resource Board economic analysis of the Advanced Clean Cars II regulation,[62] which estimated costs for car and light truck PHEVs and BEVs with varying levels of electric mileage. For PHEVs, the analysis projected costs for vehicles with 25 miles of EV range and 50 miles of EV range. For BEV costs, assumed ranges of 200 miles and 300 miles were used. These assumed ranges were used to calculate the effective battery size of the given vehicle in kilowatt-hours, which is the main driver of vehicle cost. These estimated EV costs were compared against comparably sized ICE vehicles and their manufacturer suggested retail price (MSRP). The cost differential between ICE vehicles and EVs represent the incremental costs used in the framework. The resulting incremental LD ZEV costs used in the analysis framework are given in Table 16.

Table 16: Incremental ZEV Purchase Costs (2020$)

	2020	2030	2040	2050
Passenger Car	$5,595	$2,348	$1,440	$1,557
Light Truck	$7,835	$3,148	$1,928	$2,085

Incremental maintenance costs for ZEVs compared with baseline diesel and gasoline vehicles were calculated for passenger cars and light trucks using the same weighting factors as for vehicle purchase costs. Maintenance costs are assumed to be $0.017/mi lower for ZEV passenger cars, and $0.018/mi for ZEV light trucks compared to diesel and gasoline vehicles.

Fueling Infrastructure Costs

To estimate charging infrastructure needs for LD EVs, the framework uses a charging scenario model that calculates, for different vehicle types, required charging capacity (kW/vehicle) and daily peak demand[63] (kW/vehicle) based on typical daily energy use, available charging time, and charging location (home/depot-based or public). About 80 percent of light-duty vehicles (passenger cars and light trucks) are assumed to use overnight home/depot-based charging, with 9–11 hours per day available for charging. Daily peak demand per vehicle is highly dependent on when vehicles begin to plug in and charge. For this analysis, two charging scenarios were analyzed – a baseline charging scenario and a managed charging scenario. Under a baseline scenario, vehicles are assumed to plug in and start charging immediately upon arrival at work or at home. Conversely, a managed charging scenario assumes 80 percent of vehicle owners arriving home after 2:00 PM will delay charging their vehicles until after 9:00 PM. Charging is assumed to be spread out over the period of 9:00 PM to 6:00 AM.

The resulting average required charger capacity and daily peak demand under the baseline and managed charging scenarios are shown in Table 17.

[62] ERM internal analysis of ARB estimated PEV costs, for the economic analysis of the Advanced Clean Cars II Regulation, May 2021

[63] Peak demand is electrical load between 2PM and 6PM, which is the highest energy demand period (Peak) that the utility grid experiences on a given day.

Table 17: Average EV Charging Infrastructure Requirements

	Average Charger Capacity (kW/vehicle)		Daily Peak Demand (kW/vehicle	
Vehicle Type	Home/Depot	Public	Baseline Charging	Managed Charging
Passenger Car	7.2	0.52	2.14	1.24
Light Truck	7.2	0.52	2.14	1.24

Charging infrastructure costs ($/kW) were estimated for light-duty vehicles based on publicly available chargers purchased costs and represents a hard-wired Level 2 charger with an average cost of $77/kW.[cxxx] For installation costs of light-duty chargers, the framework assumes an average labor rate of $120/hour, an average of 4 hours to install the equipment and also includes an additional $50 for miscellaneous materials that could be needed for install (i.e., wire, connectors, junction boxes, etc.). This results in an estimated $55/kW of charger capacity (2020$).

To estimate total infrastructure costs each year, the number of new ZEVs purchased in that year is multiplied by the average required charging capacity of home and public chargers (kW/vehicle) and the average charger cost ($/kW).

On the basis of ERM project experience in evaluating charging implementation for electric buses, the framework assumes that EV chargers will require 12 hours/year of preventive maintenance activities for every 50 kW of capacity. Assuming a labor rate of $78/hour[64] and average annual charger utilization (MWh per kW capacity) from the charging scenario model, this equates to $3.00/MWh for light-duty vehicles. To calculate total annual infrastructure maintenance costs, these values were multiplied by total annual charging energy for each vehicle type (MWh).

Utility Impact Analysis

Based on the results of the fuel and emissions and cost analyses discussed above, the framework estimates annual incremental electric load (MW), usage (MWh), and utility revenue (2020$ millions) from EV charging under each modeled scenario. The framework then uses EIA estimates for average regional transmission and generation costs[cxxxi] and state-specific estimates of incremental peak capacity costs ($/MW-year) to estimate the utilities' cost of providing this energy.[65] By subtracting this cost from incremental revenue, the framework estimates the annual net revenue (revenue minus costs) that utilities will realize due to the incremental EVs in each scenario, compared with the baseline.

In general, a utility's costs to maintain its distribution infrastructure increases each year with inflation, and these costs are passed on to utility customers in accordance with rules established by the state public utilities commission via periodic increases in residential and commercial electric rates. The net revenue resulting from increased EV charging can be used to support system operations, in effect putting downward pressure on future rate increases for all utility customers, whether they are EV owners or not. Based on estimated net revenue and estimated total system throughput, the framework estimates the potential reductions in future rates for commercial and residential customers from increased EV penetration in each policy scenario.

[64] Bureau of Labor Statistics, 49-2095: Electrical and Electronics Repairers, Powerhouse, Substation, and Relay; mean hourly wage of $39.08 (2020), plus 100% overhead.

[65] Peak capacity cost estimates are generated from a range of sources, depending on the State, including capacity market prices, utility integrated resource plans, and estimates from the regional transmission operator.

Infrastructure Gap Analysis

As of December 2021, there were 1,488 publicly accessible charging stations in the State of Colorado with nearly 2,900 Level 2 charging ports and 574 direct current fast-charging (DCFC) ports (>50 kW).[cxxxii] Almost 46 percent of these DCFC ports are Tesla superchargers that can be used only by Tesla owners currently,[66] leaving 315 DCFC ports fully available to any vehicle. DCFC ports can provide rapid charging of electric vehicles, with some able to replenish 80 percent of a vehicle's battery capacity in under an hour.

To estimate charging infrastructure needs, the framework uses charging scenario models that calculate, for different vehicle types, the required number of chargers and charger capacity (kW/vehicle) based on typical daily energy use, available charging time, and charging location (depot-based or public). Table 18 summarizes assumed charging locations and resulting estimates of charging needs (ports per 1,000 ZEVs).

Table 18: Charging Infrastructure Needs (Ports per 1,000 ZEV)

Metric			Passenger Cars	Light Trucks
Charging Location	Depot		80 %	80 %
	Public		20 %	20 %
Depot Chargers	Average kW/port		7.7	7.7
	Ports/1,000 ZEV		818	818
Public Chargers	Ports/1,000 ZEV	150kW	17	17
		500 kW	2	2

[66] Tesla is beginning a pilot program to allow non-Tesla vehicles to use their Supercharger network with the goal of mixed vehicle usage in the near future. (https://electrek.co/2021/11/01/tesla-launches-pilot-program-for-non-tesla-evs-open-supercharger-network/)

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One Beacon Street
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Boston, MA 02108

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