



Cleaner Cars for PA

How the Zero-Emission Vehicle program would cut climate and air pollution in the Keystone State



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Executive summary

Transportation is one of Pennsylvania's leading sources of the air pollution that harms our health and contributes to global warming. One-quarter of Pennsylvania's greenhouse gas emissions come from transportation and more than a third of the nitrogen oxide emissions that contribute to harmful ozone smog come from highway vehicles.¹

To cut carbon pollution, clean our air and end our dependence on fossil fuels for transportation, Pennsylvania must begin a rapid transition to clean, zero-emission electric vehicles.

Since 1990, the Zero-Emission Vehicle (ZEV) program has been one of states' most effective tools for spurring the development and adoption of electric and other clean vehicles. The ZEV program sets sales requirements for automakers, requiring them to sell a steadily increasing percentage of zero-emission and near-zero-emission vehicles over time.

By adopting the ZEV program with a strong 100% electric vehicle sales goal, Pennsylvania can cut carbon pollution from light-duty cars and trucks by 75% by 2050 versus today's levels, or by nearly two-thirds compared to a business-as-usual scenario with limited electrification after 2026.

In February 2021, Governor Tom Wolf put Pennsylvania on the path to adopting the ZEV program, directing the Department of Environmental Protection's Bureau of Air Quality to begin drafting a rule requiring automakers to sell a certain percentage of EVs.² Pennsylvania would join 13 other states in adopting the Zero-Emission Vehicle program if it were the next to do so.³

Transportation is a major source of pollution in Pennsylvania.

- Transportation produced 24% of Pennsylvania's greenhouse gases in 2017, with motor gasoline use in light-duty vehicles accounting for the majority of transportation emissions.⁴
- Vehicles are also big contributors to poor air quality. Highway vehicles produced more than one-third of Pennsylvania's emissions of smog-forming nitrogen oxides in 2017, as well as nearly 5% of primary emissions of small particle pollution.⁵ Air pollution from smog and small particle matter has been linked to respiratory and cardiovascular damage, worsened mental health and increased cancer risk.⁶
- A 2020 study by researchers at the Massachusetts Institute of Technology estimated that 4,800 Pennsylvanians died prematurely due to exposure to air pollution in 2018 – the highest per capita rate of premature death of any state in the country.⁷

Clean electric vehicles are ready to roll in Pennsylvania.

- There are 19 models of all-electric light-duty vehicles available in the U.S. as of early 2021.⁸ Dozens more models – including pickups and SUVs – are on the way in the next several years.⁹
 - Forty new all-electric light-duty models are expected in the U.S. by 2023, including a growing array of electric pickups and SUVs. Almost 100 models should be available by the end of 2024.¹⁰

- GM announced it intends to sell only electric light-duty vehicles by 2035, and Volvo committed to doing so by 2030.¹¹
- The past decade has seen dramatic declines in the cost of electric vehicle batteries and dramatic increases in vehicle range – making EVs an increasingly attractive option for Pennsylvanians.
 - The median EV model sold in 2020 traveled 250 miles on a charge – more than three times as far as the median EV sold in 2011.¹²
 - The price of lithium-ion batteries fell by 89% between 2010 and 2020. By 2023, average battery pack prices are predicted to fall to around \$100/kWh – a price point at which the sticker price of EVs will become competitive with conventional vehicles.¹³
 - The total cost of ownership of EVs is already lower than gasoline powered vehicles. EVs typically save users between \$6,000 and \$10,000 over the lifetime of the vehicles due to lower fuel and maintenance costs.¹⁴
- Electric vehicles running off of Pennsylvania’s existing grid produce less than a third of the carbon dioxide per mile of conventional gasoline vehicles.¹⁵ EVs will only become cleaner as more renewable energy comes onto the grid.

The ZEV program is a proven tool for accelerating the deployment of clean electric vehicles.

- Part of the Advanced Clean Cars Program (which includes the Low-Emission Vehicle program Pennsylvania adopted in 2001), the ZEV program requires car manufacturers to sell electric vehicles and other advanced vehicles in states that have adopted the program.¹⁶
- The ZEV program currently requires automakers to obtain credits corresponding to their production of electric and plug-in hybrid vehicles. By 2025, electric vehicles could comprise up to 8% of light-duty vehicle sales in states with the program.¹⁷

- Reflecting the maturity of electric vehicle technology and the urgent need for climate action, the ZEV program will become even more ambitious after 2025, with California having announced its intention to move to 100% sales of zero-emission light-duty vehicles by 2035.¹⁸

Adopting the Zero-Emission Vehicle program will cut carbon pollution and help clear Pennsylvania’s air.

- A ZEV program that drives the transition to 100% zero-emission light-duty vehicle sales by 2035 will produce large-scale reductions in greenhouse gas emissions.
 - The program would lead to 75% lower carbon dioxide emissions from cars and light trucks in 2050 compared to 2020.
 - These 2050 emissions would be 63% lower under the ZEV policy scenario than the business-as-usual scenario. (See Figure ES-1.)
 - The program will lead to a 17.8 million metric ton reduction in carbon emissions from Pennsylvania light-duty vehicles in 2050 alone. This represents about 8% of the emissions reductions required to meet Pennsylvania’s target of reducing greenhouse gas emissions to 80% below 2005 levels by 2050.
- A transition to electric vehicles will also help to clear Pennsylvania’s air. According to the state’s 2019 Electric Vehicle Roadmap, a rapid transition to EVs would lead to reduced emissions of key air pollutants from light-duty vehicles by 2033, including:
 - A 27% reduction in emissions of smog-forming nitrogen oxides;
 - A 15% reduction in emissions of small particulates (PM_{2.5});
 - A 27% reduction in volatile organic compound emissions;
 - A 25% reduction in sulfur dioxide emissions.¹⁹

- The emission reductions delivered by electric vehicles would even be greater if the commonwealth transitions to an electricity grid powered by clean, renewable energy.

Pennsylvania should move to adopt the Zero-Emission Vehicle program and other policies to accelerate the introduction of clean electric vehicles.

In addition to adopting the ZEV program proposed by the governor, Pennsylvania should implement other policies to accelerate electric vehicle deployment, including:

- Expanding Governor Wolf’s climate change executive order with more ambitious ZEV targets for the state fleet, including 50% ZEVs by 2030 and 100% ZEVs by 2035.²⁰
- Increasing rebates for ZEV purchases.

- Adopting EV-ready building code amendments to ensure that new homes and commercial buildings are equipped for EV charging.
- Passing a planning bill to support and expand EV infrastructure.
- Developing education and outreach efforts for consumers and dealers to raise awareness of EV technology and available incentives.
- Providing technical assistance and resources for fleet managers looking to electrify their fleets.
- Collaborating with utilities to ensure that EVs are integrated in a way that optimizes the grid.
- Joining the Transportation and Climate Initiative Program and collaborating with neighboring states on reducing transportation emissions.

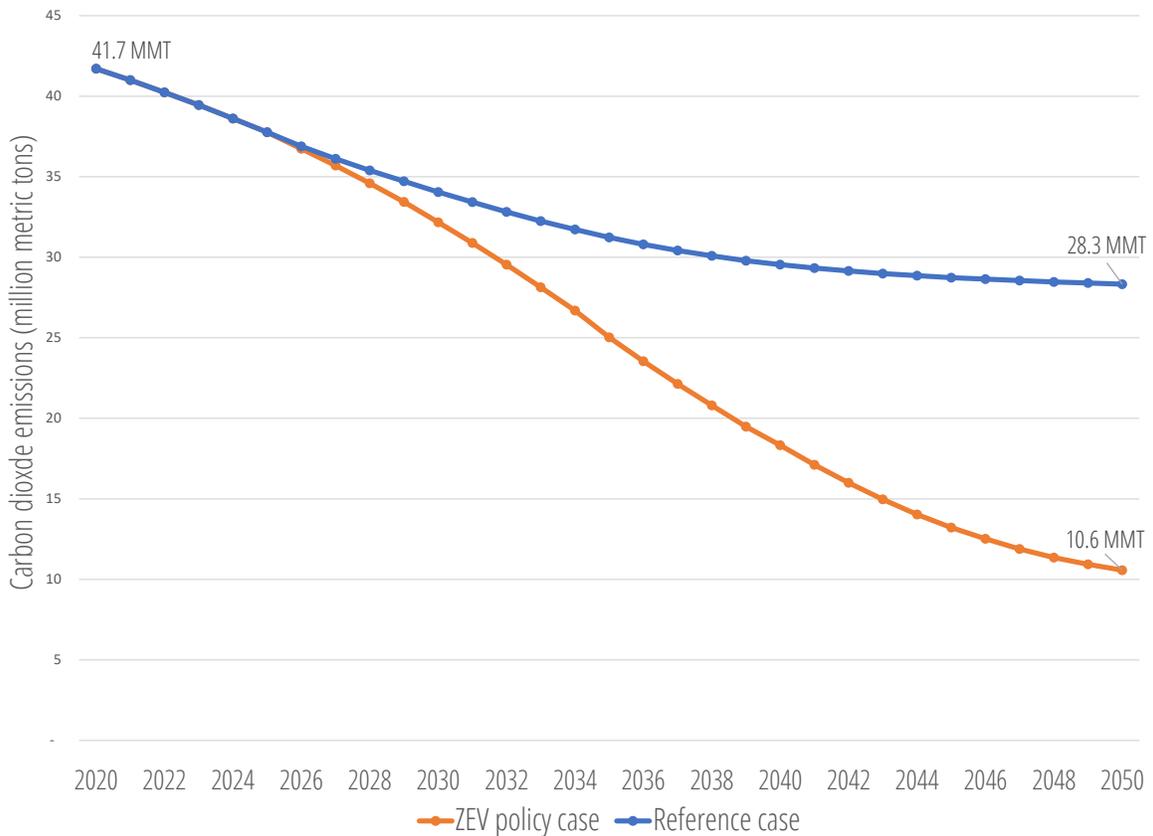


Figure ES-1. Carbon dioxide emissions in Pennsylvania from light-duty cars and trucks under business-as-usual reference case and ZEV policy case

Introduction

Imagine a future in which you never have to stop at a gas station. Or get an oil change. A future in which the next car you buy emits nothing from its tailpipe. In fact, it might not even have a tailpipe at all.

That future – a future of electric vehicles for Pennsylvania – is on its way. How quickly it will get here, and how soon we will enjoy the climate and health benefits of that future, is up to us.

The last decade has seen dramatic improvement in electric vehicle technology. Today's EVs are cheaper, go farther on a charge, and come in a wider variety of styles than ever before.²¹

The improvements of the last decade, while substantial, are just the beginning. Electric vehicles already cost less than gasoline vehicles over a lifetime of operation, thanks to lower fuel and maintenance costs.²² By the middle of this decade, they may have a lower sticker price than comparable conventional cars.²³ Charging networks continue to expand and the travel range of EVs continues to grow, making it easier for drivers to get where they're going reliably. The performance of EVs on the road – which already earns praise from drivers – continues to improve as well.

Pennsylvania has the option to experience that future as it unfolds by adopting the Zero-Emission Vehicle (ZEV) program already in place in 13 states. States with the ZEV program tend to receive new and best-selling EV models first, giving their residents access to a much greater inventory of the most popular zero-emission vehicles available.²⁴

But those who drive EVs aren't the only beneficiaries of the ZEV program. Accelerating electric vehicle deploy-

ment benefits everyone who breathes the air, or who worries that their children and grandchildren will grow up in a world of extreme heat, destructive storms and increased risk of flooding and drought caused by global warming.

Electric vehicles produce vastly less climate-altering carbon pollution than conventional cars and emit none of the smog- and soot-forming pollutants from their tailpipes that make the air in our cities difficult and dangerous to breathe. As Pennsylvania shifts its electricity mix to rely increasingly on clean, renewable sources of energy, the clean air benefits of EVs will only grow greater.

Despite the advantages of EVs, however, there is no guarantee that Pennsylvania will make the transition to clean, electric transportation in time to help prevent the worst impacts of global warming. It will take hard work, strong commitment and bold action. Pennsylvania's adoption of the Zero-Emission Vehicle program is a key step that the commonwealth can take to bring that future of clean transportation one step closer to reality.

For generations, people have dreamed of a day when a trip in a car didn't mean polluting the air our children breathe or pressing the accelerator on climate disaster. Thanks to years of forward-thinking policies such as the ZEV program and rapid technological progress, that day is nearly here.

A future of clean transportation is now available to us. With dirty air and the climate crisis threatening our future, we can't afford to wait for that future to arrive. And by adopting the Zero-Emission Vehicle program and other smart policies to accelerate EV deployment, we won't have to.

Pennsylvania's cars and trucks foul our air and harm the climate

Pennsylvania's transportation system – and, in particular, our roughly 11 million cars and light trucks – pollute our air and are a leading source of the carbon pollution that is contributing to the warming of the planet.

Global warming is having real impacts on Pennsylvania now, and will only become more disruptive in the future if we fail to act.

Air pollution harms our health

Ozone “smog,” particulate soot and other forms of air pollution contribute to a host of health problems across Pennsylvania and even increase the risk of premature death.

A 2020 study by researchers at the Massachusetts Institute of Technology estimated that 4,800 Pennsylvanians died prematurely due to exposure to air pollution in 2018 – the highest per capita rate of premature death of any state in the country.²⁶

Pennsylvania cities continually rank among the worst in the nation for air pollution impacts.

- The Pittsburgh area ranked fourth in the nation for premature deaths caused by air pollution in a 2019 analysis by the American Thoracic Society and the NYU Marron Institute of Urban Management.²⁷ Nine Pennsylvania counties – located in the

Philadelphia, Pittsburgh and Allentown-Bethlehem-Easton metropolitan areas – received an “F” grade for air quality in the American Lung Association's most recent “State of the Air” report.²⁸

- In 2018, the Philadelphia, Pittsburgh, Allentown-Bethlehem-Easton and Harrisburg-Carlisle metropolitan areas each posted at least 85 days on which air pollution levels were elevated enough to cause public health concern, according to PennEnvironment Research & Policy Center's “Trouble in the Air” report.²⁹

Global warming threatens Pennsylvania's future

Global warming is here and having real impacts on Pennsylvania's people and environment. Those impacts will only grow more severe if we fail to take action to curb carbon pollution.

Average temperature in Pennsylvania has risen by nearly 2°F since 1901.³⁰ Increasing precipitation – especially in the form of extreme downpours – has raised concerns about increases in flooding. In the Northeastern United States, the frequency of heavy precipitation events has increased by more than 50% since the 1950s.³¹

The impacts of climate change will only become more severe over time. Every county in Pennsylvania is pro-

jected to get warmer and wetter by 2050. Average rainfall and extreme precipitation are expected to rise between 8% and 12%, while average temperature could rise 4.9°F above 2000 levels.³²

That warming will affect many aspects of life in Pennsylvania. Air pollution and water pollution will likely worsen as hotter temperatures aid the formation of ozone “smog” and as changing precipitation patterns carry more nutrient and sediment runoff pollution into Pennsylvania’s rivers, lakes and streams.³³ Stronger tropical storms threaten damage to property and infrastructure.³⁴

Higher temperatures will disrupt agriculture and lead to an increase in heat-related deaths.³⁵

Transportation is a leading contributor to dirty air and global warming

Pennsylvania’s transportation system is a leading contributor to our chronically dirty air and to global warming, which threatens our future.

Transportation produced 24% of Pennsylvania’s greenhouse gas emissions in 2017, with motor gasoline use in cars and light trucks accounting for the majority of those emissions.³⁶

Transportation emissions in Pennsylvania are lower than in 2005, thanks to improvements in vehicle fuel economy and the state’s Low Emission Vehicles program (see page 15). However, they represent a larger share of the commonwealth’s total emissions than in 2005. (See Figure 1.)

Transportation is also a big contributor to poor air quality. Highway vehicles produced more than one-third of Pennsylvania’s emissions of smog-forming nitrogen oxides in 2017, as well as nearly 5% of primary emissions of small particle pollution.³⁹

These air pollutants have been linked to respiratory and cardiovascular damage, worsened mental health and increased cancer risk.⁴⁰

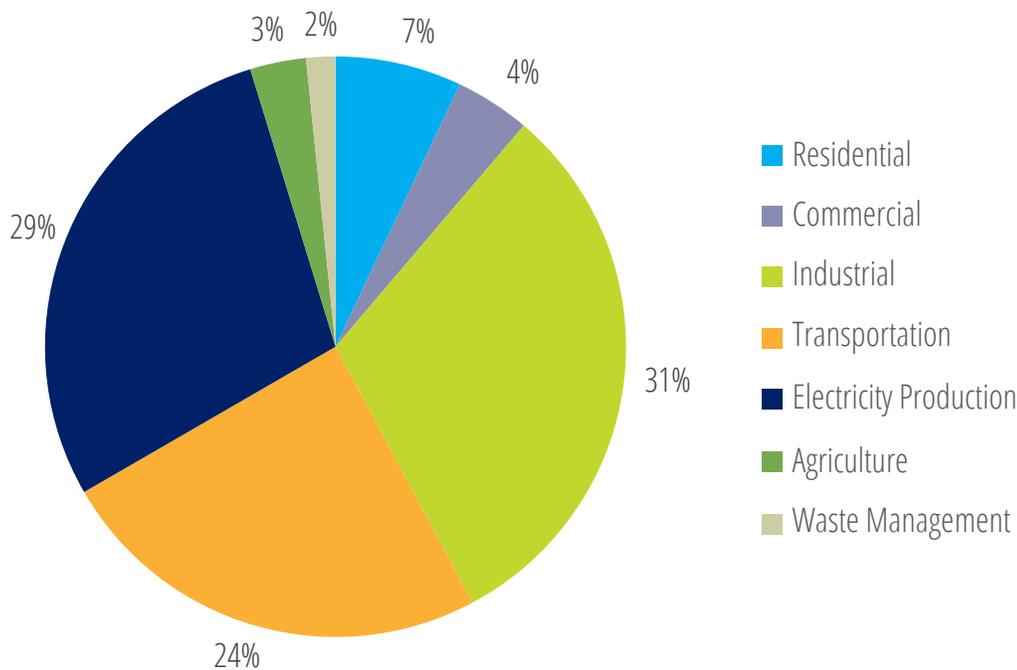


Figure 1. Pennsylvania greenhouse gas emissions by sector³⁷

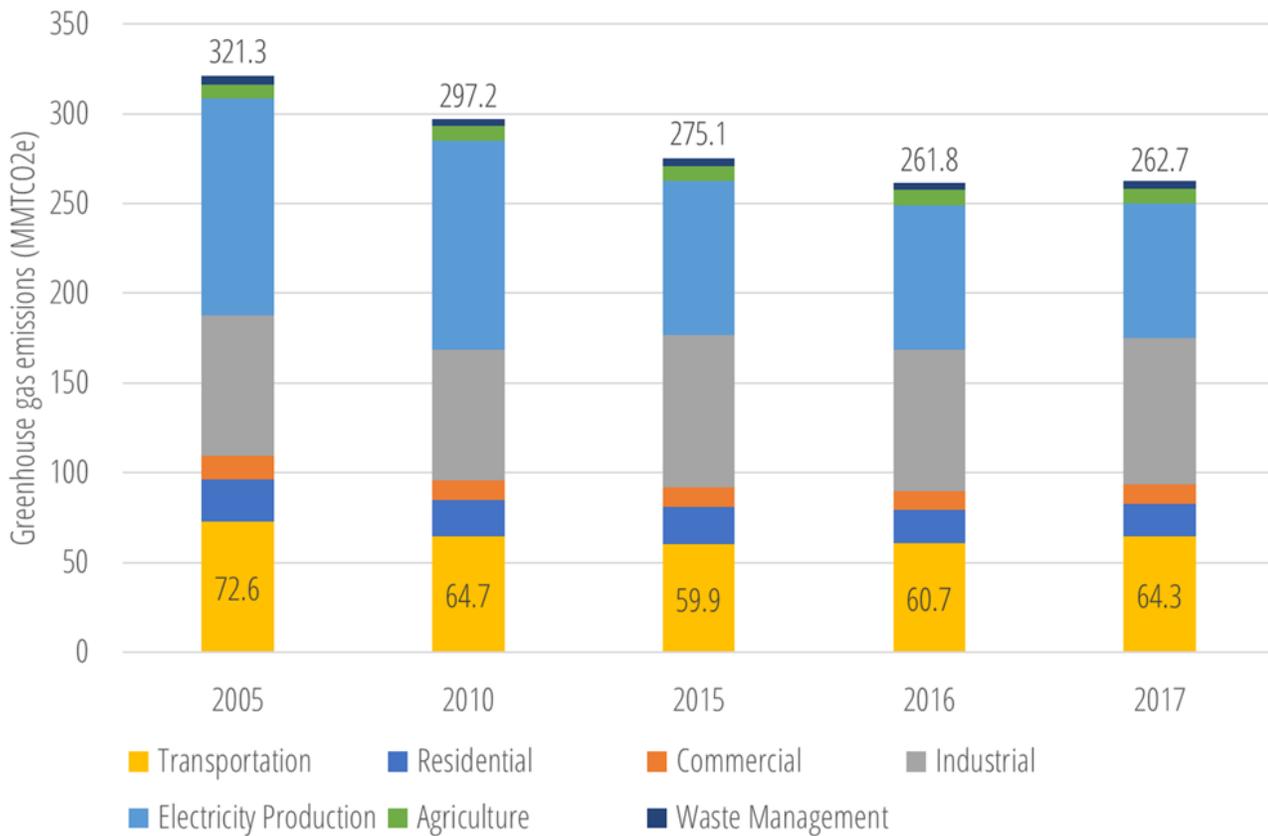


Figure 2. Pennsylvania greenhouse gas emissions by sector³⁸

Cleaning up Pennsylvania’s air and addressing global warming require us to take strong action to clean up the cars and trucks traveling over our roads. In recent decades, thanks in part to Pennsylvania’s leadership in adopting the Low-Emission Vehicle program, there has been major progress in reducing pollutant emissions from cars and light trucks. But our continued use of oil to power our transportation system puts a limit on the amount of progress possible.

Thankfully, a new generation of clean, electric vehicles is ready to roll. By accelerating our adoption of electric vehicles, Pennsylvania can address two problems at once – reducing emissions of pollutants that harm our health and slashing our global warming pollution.

Electric vehicles are clean and ready to roll

Electric vehicles are dramatically cleaner than vehicles that run on fossil fuels. They are also rapidly becoming cheaper and capable of traveling longer distances on a single charge – making them a convenient and increasingly affordable option for Pennsylvanians.

Electric vehicles are clean

Electric vehicles are vastly more energy efficient than internal combustion engine vehicles, meaning that they produce fewer emissions per mile, even when powered by an electric grid that still uses fossil fuels. And with no tailpipe, electric vehicles produce no emissions from fuel combustion while driving.

The average all-electric vehicle in Pennsylvania produces less than a third of the greenhouse gas emissions per mile compared to a typical gasoline-powered vehicle, according to the U.S. Department of Energy.

Including emissions from manufacturing, electric vehicles produce about half the greenhouse gas emissions over their lifetimes as conventional gasoline-powered vehicles.⁴²

Electric vehicles are likely to become cleaner over time as Pennsylvania replaces highly polluting coal-fired power plants with cleaner forms of electricity such as solar and wind power. Joining the Regional Greenhouse Gas Initiative (RGGI) – a program designed to limit carbon pollution from power plants in the Northeast and Mid-Atlantic states – as Pennsylvania is

currently considering, would help to ensure that the region’s electricity supply will continue to become cleaner over time.

Electric vehicles are becoming cheaper and more effective

Electric vehicles have always had the benefit of being clean. But over the last decade, they have also become affordable. And with more models on the market able to travel longer distances between charges, EVs are able to meet the travel needs of more and more Pennsylvanians.

Batteries represent a sizeable share of the cost of EVs, and battery prices have fallen sharply over the past decade, with the price of lithium-ion battery packs falling by 89% between 2010 and 2020. By 2023, average pack prices are predicted to fall to around \$100/kWh – a price point at which “automakers should be able to produce and sell mass market EVs at the same price (and with the same margin) as comparable internal combustion vehicles in some markets,” according to a recent forecast by Bloomberg New Energy Finance.⁴³

Even if they cost more up front for the time being, electric vehicles are often cheaper to own and operate over their lifetime due to lower costs for fuel and maintenance. On a per-mile basis, electric vehicles cost half as much to fuel as gasoline-powered vehicles in Pennsylvania. As of March 2021, the per-mile

price of fueling up an electric vehicle in Pennsylvania was equivalent to \$1.20 per gallon, compared with an average price for regular gasoline of \$2.81 per gallon.⁴⁴ EVs also require less maintenance, with no need for oil changes and fewer moving parts. Consumer Reports estimates that the cost of maintaining an electric or plug-in hybrid vehicle is about half that of a conventional gasoline-powered vehicle.⁴⁵

Electric vehicles are not only increasingly affordable, but they also grow more capable with every passing year. The median EV model sold in 2020 traveled 250 miles on a charge – more than three times as far as the median EV sold in 2011.⁴⁶ Even at the shorter travel ranges of a few years ago, electric vehicles could meet the needs of 90% of drivers.⁴⁷ With longer travel ranges and greater availability of public EV charging – including fast charging – EVs are now able to meet the needs of almost every driver in America.

At the same time, automakers are manufacturing a growing array of EV models. There were 19 models of all-electric light-duty vehicles available in the U.S. in 2020.⁴⁹ Dozens more models – including pickups and SUVs – are on the way in the next several years.⁵⁰ Forty new all-electric models are expected in the U.S. by 2023, and almost 100 models should be available by the end of 2024, including a growing array of electric pickups and SUVs.⁵¹

Global sales of electric cars grew in 2020, rising by 43% even as the coronavirus pandemic pushed overall car sales down 20%.⁵² In the U.S., sales of plug-in vehicles (full EVs and plug-in hybrids) increased by 4% amid a 15% drop in overall vehicle sales.⁵³ Analysts are bullish on the future of U.S. electric vehicle sales, which could increase 70% in 2021.⁵⁴ The Jaguar brand will be fully electric by 2025, Volvo will be by 2030, and GM plans to sell only electric cars by 2035.⁵⁵

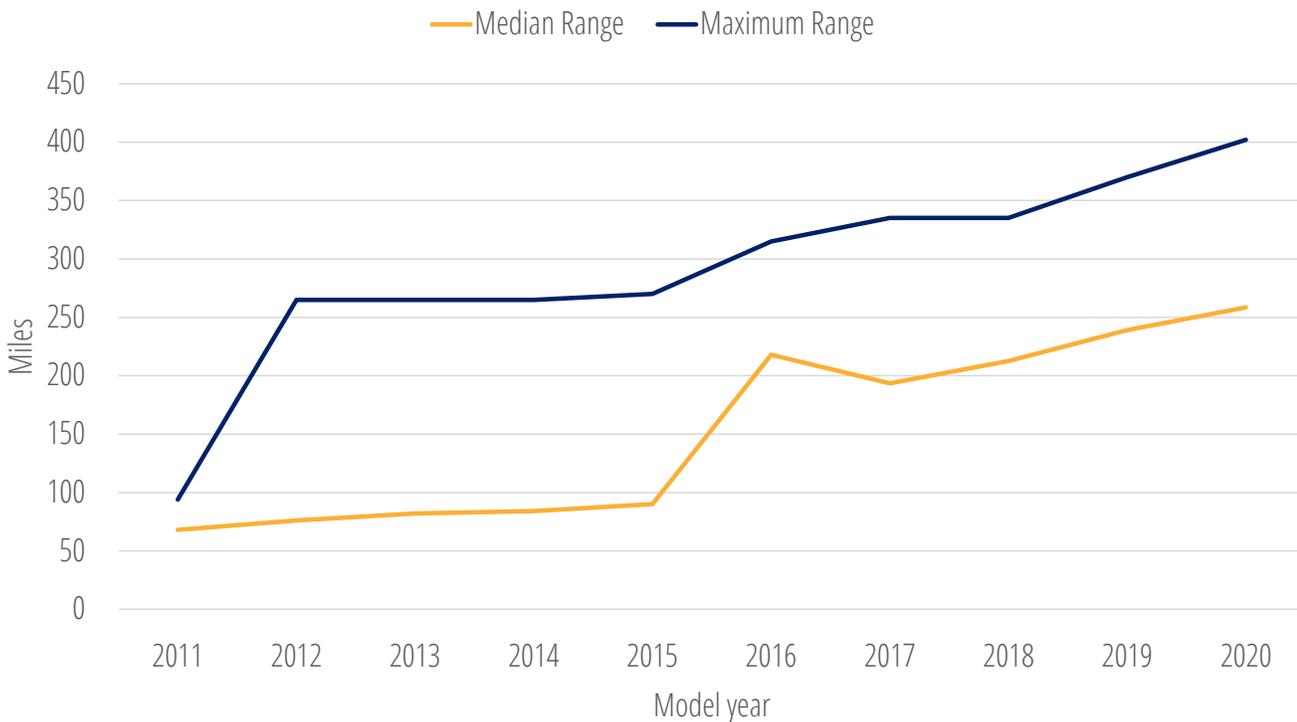
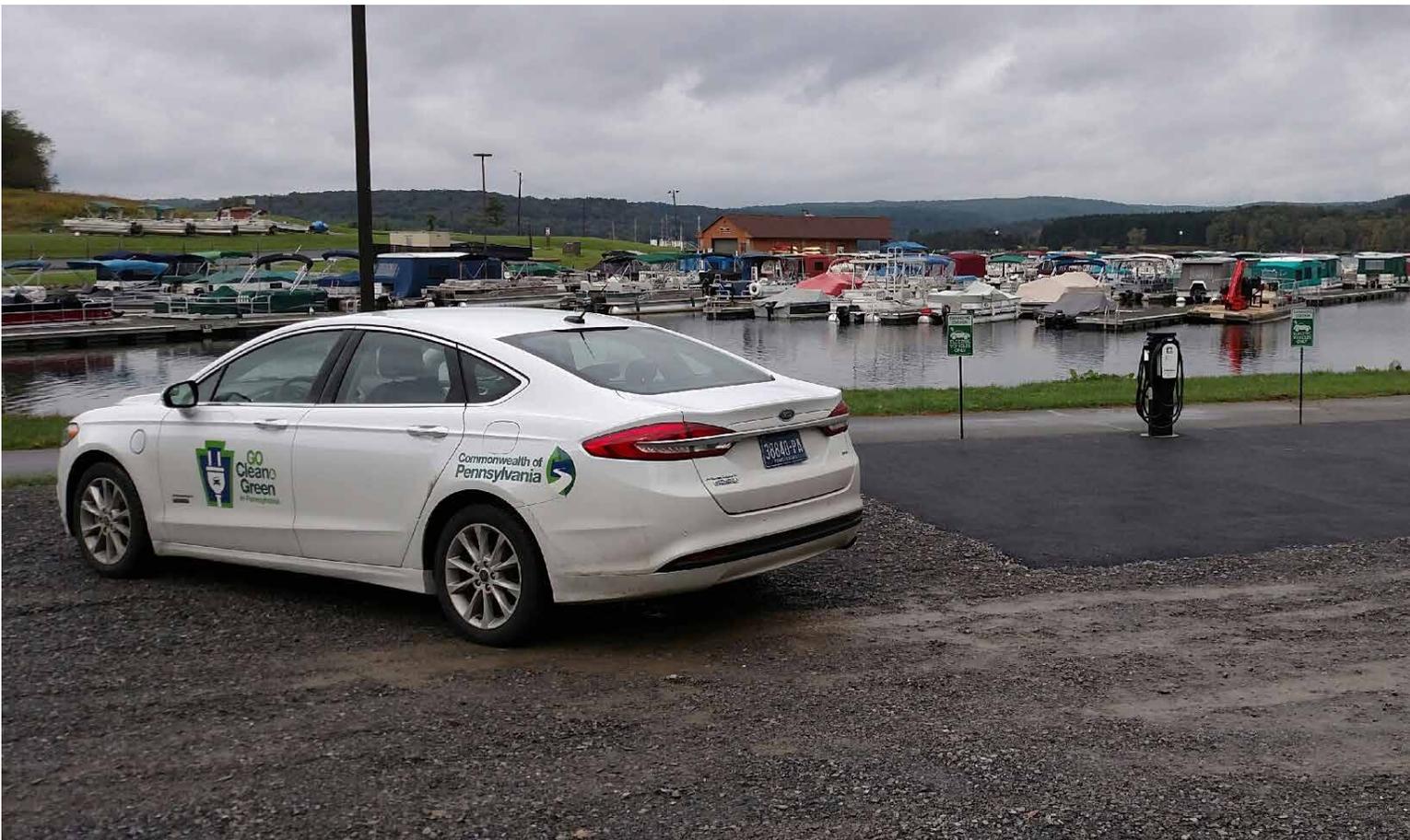


Figure 3. Range of electric vehicles on sale in United States⁴⁸



A Department of Conservation and Natural Resources plug-in hybrid electric vehicle at Prince Gallitzin State Park's public EV charging station.

However, non-ZEV states may not initially see the full selection of EVs on their auto lots. Automakers sometimes make their newest models only available in ZEV states, where they will count towards ZEV targets. Furthermore, customers and dealerships in ZEV states are more likely to be familiar with these cars and their selling points. According to a 2020 survey, popular electric vehicles were more widely available in Maryland, which has the ZEV program, than in neighboring Virginia, which did not have the program at the time of the survey.⁵⁶

The transition to electric vehicles is only just beginning in Pennsylvania. At the end of 2019, there were 10,875 registered electric vehicles on the road.⁵⁷ But with prices falling, ranges rising and charging infrastructure expanding, the moment has come to accelerate the transition from dirty gasoline-powered vehicles to clean electric ones.

Pennsylvania must speed up electric vehicle adoption to meet our climate goals

Pennsylvania has committed to a major reduction in climate pollution, laying out policies and a realistic timeline for how and when to achieve that reduction. Joining the ZEV program would significantly reduce Pennsylvania's greenhouse gas emissions while making the commonwealth cleaner and healthier.

In 2019, Governor Tom Wolf issued an executive order pledging the commonwealth's leadership in the fight against global warming. Executive Order 2019-01 set a goal of achieving a 26% reduction of net greenhouse gas emissions statewide from 2005 levels by 2025 and an 80% reduction by 2050 – similar to the United States' commitment under the Paris Climate Agreement.⁵⁸ It also directs the state government to electrify 25% of the state's passenger car fleet with battery and plug-in hybrid cars by 2025.

“I am proud to join with states that are leading the way towards new climate solutions, and taking concrete actions to reduce greenhouse gas emissions.”

–Pennsylvania Governor Tom Wolf

In April 2019, Pennsylvania released the fourth version of its Climate Action Plan, an updated set of goals and strategies to minimize the disruptions of a warming planet while also reducing the greenhouse gas emissions that are causing them.

That same day, Governor Wolf joined the U.S. Climate Alliance, a bipartisan group of 25 governors whose states will work to advance the goals of the Paris Agreement, saying, “I am proud to join with states that are leading the way towards new climate solutions, and taking concrete actions to reduce greenhouse gas emissions.”⁵⁹

Pennsylvania is working to clean up transportation emissions

Pennsylvania has taken several actions to clean up transportation as part of the commonwealth's overall effort to address global warming.

Among the most significant actions are Pennsylvania's adoption of the Low-Emission Vehicle (LEV) portion of the Advanced Clean Cars Program, which sets standards for the reduction of greenhouse gas emissions and other pollution from vehicle tailpipes. Fifteen states including Pennsylvania have adopted the greenhouse gas and criteria pollutant regulations in the LEV program.⁶⁰ State adoption of the program during the 2000s helped drive national adoption of strong clean cars standards during the Obama administration that have led to a significant increase in vehicle fuel economy and reduction in per-mile greenhouse gas emissions. In the five years after

2014, 11 of the top 14 automakers improved their fuel economy, even as bigger cars increased their share of the market.⁶¹ Since 2004, fuel economy has increased 29% and CO₂ emissions per mile have fallen 23%.⁶² More recently, Pennsylvania has taken the next step toward cleaning up transportation by advancing adoption of electric vehicles. In 2019, Pennsylvania issued an Electric Vehicle Roadmap laying out a strategy for accelerating electric vehicle adoption in the commonwealth.⁶³ In 2020, Pennsylvania signed onto a joint memorandum of understanding with 15 states and Washington, D.C., to stimulate the market for electric medium- and heavy-duty zero-emission vehicles. The voluntary initiative seeks to boost development and production of electric vans, trucks and buses, with a goal of 100% zero-emissions heavy-duty vehicles by 2050.⁶⁴ As part of the group, Pennsylvania is developing a plan to identify barriers and solutions to advancing widespread transportation electrification within the commonwealth.

Pennsylvania is also a participant in the Transportation and Climate Initiative (TCI), a collaboration of 12 eastern states and Washington, D.C., committed to acceler-

ating the transition toward cleaner transportation.⁶⁵ In December 2020, Massachusetts, Rhode Island, Connecticut and Washington, D.C. announced they would be the first states to move beyond the planning stage and create the TCI Program, which will establish a legally binding cap on carbon pollution from transportation. This will also create a long-term funding source for reinvestment in clean transportation.⁶⁶

Meeting climate goals will require bold new action

Despite recent progress, Pennsylvania is falling short of its climate goals. The 2018 Climate Action Plan listed over 100 leadership actions on climate and quantified the top 15 most impactful actions for reducing greenhouse gases. Even if these actions were all enacted, the commonwealth would still fail to meet both its 2025 and 2050 emissions goals.⁶⁷

A 2020 analysis by Environmental Defense Fund found that many states, Pennsylvania among them, are not on track to deliver on their climate commitments. These states will need to institute additional policies to close

Photo: Penn State



An EV charging station on the University Park campus of Penn State.

the “emissions gap” between their projected emissions and their goals. In 2030, Pennsylvania is projected to overshoot its emissions benchmark by the equivalent of 82 to 101 million metric tons of CO₂.⁶⁸ The report notes that states have considerable capacity to act on their own to close their emissions gaps, through both legislative and regulatory action.⁶⁹

On February 19, 2021, the Pennsylvania Department of Environmental Protection announced that the commonwealth intended to improve consumer access to electric vehicles by joining the ZEV program. Governor Wolf directed the Bureau of Air Quality to “amend the Pennsylvania Clean Vehicles Program to establish a requirement for automakers to include light-duty electric vehicles as a percentage of their model offerings.”⁷⁰ The proposed rule and program could be presented to the Environmental Quality Board for consideration by fall 2021.

Bold action will be needed to meet Pennsylvania’s climate goals and do its part in the effort to prevent the worst impacts of global warming. With transportation a major source of emissions, speedily adopting the Zero-Emission Vehicle program can make a significant difference.

The Zero-Emission Vehicle program will bring cleaner air and cut carbon pollution

The Zero-Emission Vehicle program – adopted by 13 states around the country – is a powerful tool that Pennsylvania can use to accelerate the transition to electric vehicles. A program that began in 1990 with the intent to spur the development of advanced technology for electric vehicles, it is evolving into a program to accelerate and guide the transition away from gasoline-powered cars. By adopting the ZEV program, Pennsylvania can achieve powerful benefits for the climate while cleaning our air.

What is the ZEV program?

The ZEV program is part of a suite of clean vehicles policies known as the Advanced Clean Cars Program. Originally adopted by California under the power granted to the state by the Clean Air Act to adopt stronger clean air standards, the Advanced Clean Cars Program includes the Low-Emission Vehicle (LEV) program, which regulates emissions of smog- and soot-forming pollutants and greenhouse gases from vehicles, as well as the ZEV program. Historically, emissions standards under the LEV program have been stronger than those at the federal level, while there is no federal equivalent to the ZEV program.

States with air pollution problems have the power under Section 177 of the federal Clean Air Act to adopt the Advanced Clean Cars Program. Currently, 15 states, including Pennsylvania, have adopted the Low-Emission Vehicle portion of the program, while 13 of those states – all of them except for Pennsylvania and Delaware – have also adopted the ZEV program.⁷¹ The leaders of Nevada, Minnesota and New

Mexico have also recently announced their intention to join the ZEV program, and Virginia joined in March 2021.⁷²

The ZEV program is a “technology forcing” regulation, meaning that it has been designed to drive the development and deployment of advanced automotive technologies. While the LEV program has been remarkably successful in driving emission reductions from internal combustion engine vehicles, there are limits to the ability to clean up cars that are powered directly by fossil fuels. To achieve a future of clear skies and net-zero greenhouse gas emissions, Pennsylvania and the nation must transition to vehicle technologies with the potential to produce zero emissions in their daily operation. The purpose of the ZEV program has been to bring those technologies to market.

The ZEV program was launched in 1990 with the initial goal of making ZEVs 10% of total vehicle sales in California by 2003.⁷³ The program evolved over the course of its first two decades to support the development of a wider range of vehicle technologies, including ultra-clean internal combustion engine vehicles, hybrid-electric vehicles and plug-in hybrids, in addition to pure electric vehicles. But by setting the bar high for environmental performance, the ZEV program jump-started advances in battery technology, sparking a wave of patents for electric vehicle technologies.⁷⁴ The proliferation of hybrid and plug-in hybrid vehicles spawned in part by earlier iterations of the ZEV program have helped to bring about the cheaper, more capable batteries in use in today’s electric vehicles.

The most recent version of the ZEV program, adopted in 2012, refocuses the program on its original purpose: driving the development and deployment of truly zero-emission electric vehicles.

To comply with the ZEV program, each major automaker must generate credits corresponding with the percentage of vehicles it manufactures and places for sale in a state. These credit percentages rise over time from 4.5% in model year 2018 to 22% in model year 2025 and beyond.⁷⁵ (See Figure 3.)

Credits under the program are assigned not only by number of cars sold, but also their technology and performance. Full battery electric vehicles can each earn up to four credits, depending on their range. Plug-in hybrid vehicles, also known as transitional zero electric vehicles (TZEVs), can only earn just over one credit.⁷⁶ While both plug-in hybrids and fully electric vehicles can generate credits under the program, there is a steadily increasing minimum requirement for credits earned from pure zero-emission vehicles, increasing from 2% in model year 2018 to 16% in model year 2025.⁷⁷

Because there are numerous ways to generate credits, it is impossible to estimate the percentage of fully electric and plug-in hybrid vehicles that would result from adoption of the program. The environmental policy organization Resources for the Future optimistically projects that the ZEV requirement for model year 2025 will result in 8% of light-duty vehicle sales being pure ZEVs in that year.⁷⁹ Minnesota estimates that pure and transitional ZEVs combined will make up 7.4% of light-duty sales in the state in 2025, while California expects 8%.⁸⁰

States other than California adopting the ZEV program have historically been given flexibility and leeway in meeting the requirements. Until model year 2018, a so-called “travel” provision allowed credits generated in other states to count toward California’s requirements and vice versa. That provision has largely been eliminated, a change that will drive the adoption of clean cars in states other than California.

Future ZEV requirements

Current ZEV program requirements run through model year 2025 and will remain at 2025 levels unless increased by the state of California. Given that Sec-

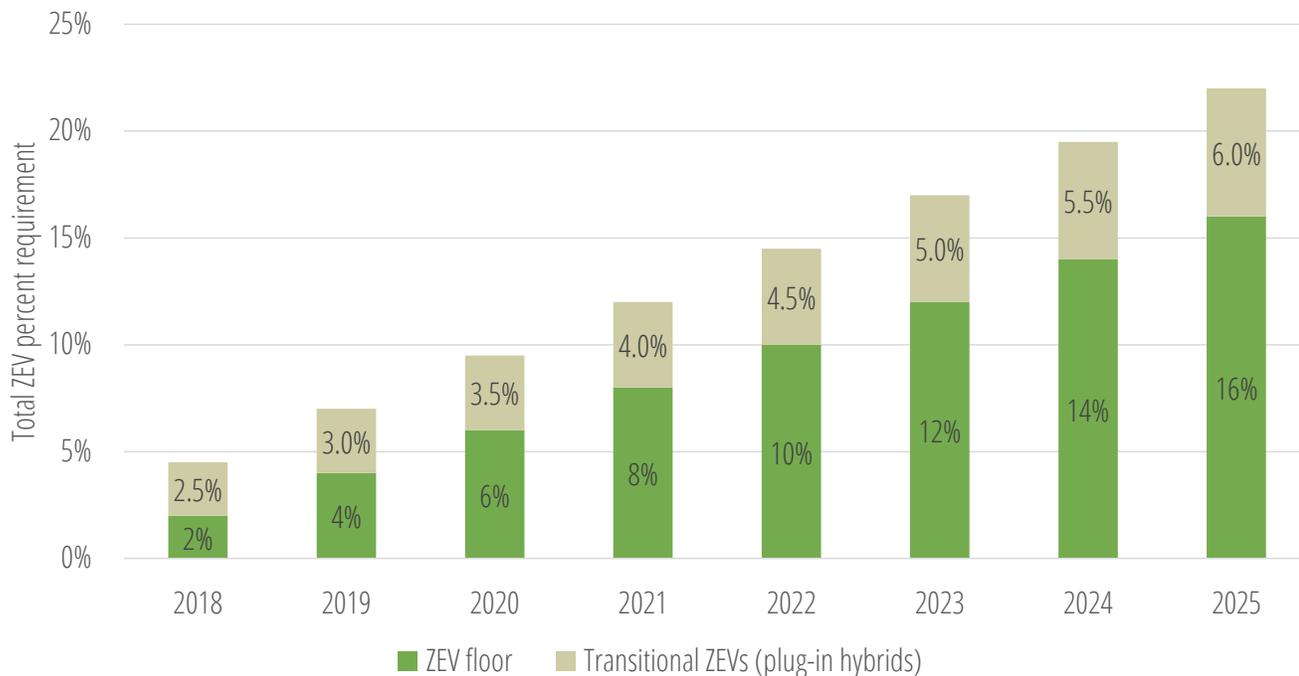


Figure 3. ZEV program credit percentage requirements⁷⁸

tion 177 of the Clean Air Act requires states adopting California's clean air standards to provide at least two model years' lead time, Pennsylvania could not implement the ZEV program until the current period of the program is nearly at its end.

California has signaled that it is likely to dramatically increase the ambition of its clean car efforts after 2025. In September 2020, California Gov. Gavin Newsom announced that California would adopt rules to phase out the sale of internal combustion engine vehicles, requiring that all new cars and passenger trucks be zero-emission by 2035.⁸¹ The executive order did not specify that the ZEV program would be the tool used to achieve that goal, but it did direct the California Air Resources Board, which develops and adopts air quality standards in the state, to develop regulations consistent with that goal "to the extent consistent with State and federal law."⁸²

California may, as it has chosen to do in the past, create a slower or less stringent compliance pathway for other states adopting the program under Section 177, but again, the content of any flexibility provisions will only become clear as California's approach to post-2025 ZEV compliance, which will likely be strongly influenced by the needs and desires of Section 177 states, becomes apparent. California expects to consider new rules for the post-2025 Advanced Clean Cars Program in December 2021.⁸³

The ZEV program can significantly reduce carbon pollution

Adopting the Zero-Emission Vehicle program will enable Pennsylvania to accelerate the transition to clean electric vehicles and dramatically reduce greenhouse gas emissions from transportation.

Adopting the ZEV program with sales targets reaching 100% zero-emission vehicles by 2035 could yield carbon dioxide emission reductions from light-duty cars and trucks of as much as 75% in 2050 compared with 2020 levels, or of 63% compared with business-as-usual 2050 emission levels. The 17.8 million metric tons of emissions reductions delivered by the program in 2050

– equivalent to shutting down almost five coal-fired power plants – would make a significant contribution to Pennsylvania's greenhouse gas emission reduction efforts.⁸⁴

To estimate the benefits of adopting the Zero-Emission Vehicle program, we constructed a spreadsheet model comparing two scenarios: a business-as-usual reference case scenario and a ZEV policy scenario.

Assumptions and scenario descriptions

The trajectory of future vehicle fuel economy and electric vehicle deployment under the reference case scenario is unclear because of the legal uncertainty introduced by the Trump administration's rollbacks of federal greenhouse gas and fuel economy standards, the EPA's attempted revocation of California's waiver to implement its greenhouse gas emissions standards and the ZEV program, and the National Highway Traffic Safety Administration's determination that California's standards are preempted by federal law.⁸⁵ While the Biden-Harris administration has directed federal agencies to review the Trump administration's clean cars rollback, it is unclear when stronger vehicle standards will be restored.⁸⁶ It is also unclear whether, and to what degree, vehicle fuel economy and greenhouse gas emission standards will be strengthened – either at the federal level or in California and other states that have adopted its standards – beyond model year 2025.

Similarly, as noted above, it is unclear what the trajectory of the Zero-Emission Vehicle program might look like after model year 2025 and the degree to which Pennsylvania or other Section 177 states might have alternative compliance options that reduce the stringency or extend the compliance timeline relative to those in place in California.

In this analysis, we compare a ZEV policy case consistent with California's stated intention to move toward 100% zero-emission vehicle sales by 2035 with a business-as-usual reference case scenario reflecting no further increase in greenhouse gas emission standards beyond 2025.

The two scenarios evaluated are:

- **Reference case scenario** – Assumes that vehicle greenhouse gas standards in place as part of the Advanced Clean Cars Program remain in effect through 2025, with no further improvements after that date.
- **ZEV policy scenario** – Assumes that Pennsylvania adopts the ZEV program for the 2026 model year, and that the ZEV program is simultaneously strengthened to guide a transition to 100% zero-emission new light-duty vehicle sales by 2035, consistent with California Gov. Gavin Newsom’s 2035 executive order. The transition to a zero-emission fleet is assumed to take place linearly, with the market share of new electric vehicles increasing by roughly 10% annually between 2026 and 2035 and electric vehicle penetration increasing equally in the car and light truck vehicle classes.

For more details on the assumptions and methods used in this analysis, please see the Methodology.

Results

A ZEV program that achieves the target of 100% zero-emission vehicle sales by 2035 would drive significant reductions in carbon dioxide emissions from light-duty cars and trucks.

Compared with 2020 levels, CO₂ emissions from cars and light trucks would fall by approximately 75% in the ZEV policy case by 2050. Some emission reductions are likely even under the “business as usual” reference case scenario, as older, less fuel-efficient cars and trucks are replaced with newer, more efficient vehicles, and as a small number of electric vehicles find their way to Pennsylvania’s roads. Those emission reductions, however, are not nearly significant enough to meet Pennsylvania’s climate goals. Adopting an ambitious ZEV program would reduce emissions by approximately 63% compared with the reference case scenario in 2050. (See Figure 4.)

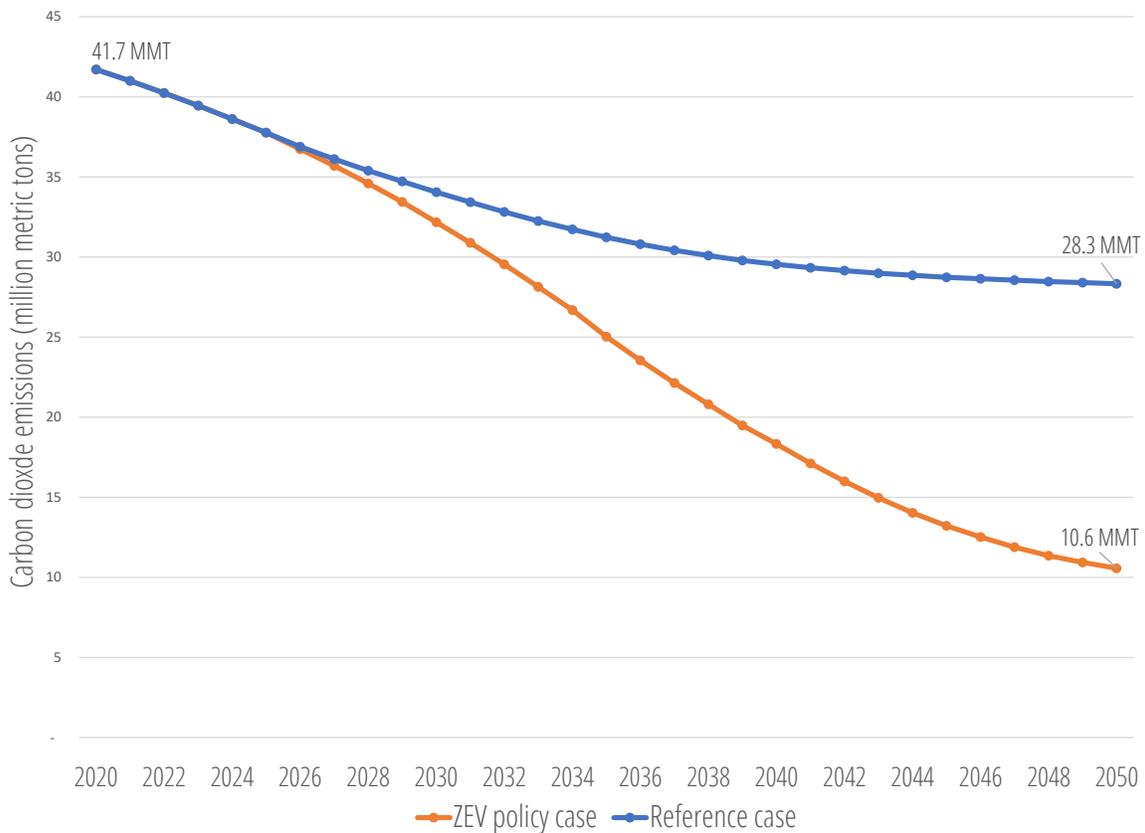


Figure 4. Emissions from light-duty cars and trucks under reference case and ZEV policy scenarios

Significant emission reductions from the ZEV program in this scenario do not begin to emerge until the late 2020s, as the vast majority of the vehicles currently on the road remain fueled by gasoline. The pace of emission reductions accelerates during the 2030s as a larger share of new vehicles is electric and as older gasoline-powered vehicles are retired. To reduce emissions from transportation sooner, Pennsylvania should consider other strategies, such as reducing vehicle travel through expanded use of public transportation, carpooling, telework, walking, biking and through electrifying heavy transportation.

Emission reductions due to the ZEV program may be even greater than shown here, as they assume the continued extensive operation of fossil fuel-fired power plants to produce electricity to power EVs. If Pennsylvania and other states were to accelerate the transition away from fossil fuel-fired electricity and toward zero-carbon renewable energy, the emission reductions delivered by the ZEV program would be even greater than shown here.

The emission reductions delivered by the ZEV program could represent a significant share of the emission reductions Pennsylvania must achieve to meet its climate commitments.

Pennsylvania's 2018 Climate Action Plan projects that, without further action, the commonwealth's net emissions of greenhouse gases will be 265 million metric tons carbon dioxide equivalent (MMT CO_2e) in 2050.⁸⁷ To meet the commonwealth's goal of reducing emissions by 80% below 2005 levels, those emissions will need to fall to 58 MMT CO_2e – a reduction of 207 MMT CO_2e below projected levels.⁸⁸

The annual reductions of 17.8 MMT CO_2 associated with adoption of an ambitious ZEV program would meet about 8.5% of the commonwealth's overall emission reduction obligation in 2050. In reality, emission reductions would likely be even greater, as the analysis above only counts reductions in carbon dioxide emissions and not emissions of other greenhouse gases from automobile tailpipes.

The Pennsylvania Climate Action Plan included a proposed action to incentivize EV adoption consistent with reaching a 31% light-duty EV market share by 2030, rising to 88% by 2050 – a less-ambitious pathway of EV adoption than modeled here.⁸⁹ The scenario was estimated to deliver emission reductions of 21.7 MMT CO_2e in 2050, suggesting that the emission reductions estimates in this analysis are conservative.

The projected electricity mix in Pennsylvania is based on the EIA's Annual Energy Outlook reference case, which envisions a conservative phase-out of fossil fuels: For example, the coal-fired power capacity in Western Pennsylvania is projected to fall from 30 to 13 gigawatts between 2020 and 2050.⁹⁰ Faster decarbonization of the power grid would yield larger emission reductions from ZEVs.

On a cumulative basis, adopting an ambitious ZEV program would deliver an estimated carbon dioxide emission reduction of 227 million metric tons between 2020 and 2050 – equivalent to nearly a full year of greenhouse gas emissions from all sources in Pennsylvania.⁹¹

A strong ZEV program will deliver cleaner air and other benefits

The adoption of a strong ZEV program would also reduce Pennsylvania's dependence on fossil fuels and bring cleaner air.

Pennsylvania's 2019 Electric Vehicle Blueprint reviewed the potential benefits of accelerated electric vehicle deployment through 2033. The blueprint's "high technology, high policy" scenario proposed a trajectory for EV sales that was somewhat more ambitious in early years and less ambitious in later years than the one used in this analysis. That scenario estimated that, by 2033, EVs would be 79% of new light-duty vehicles sold and gasoline consumption would fall by 25%.⁹²

The roadmap also projected significant reductions in well-to-wheels emissions of key air pollutants from gasoline-fueled light-duty vehicles by 2033, including:⁹³

- A 27% reduction in emissions of smog-forming nitrogen oxides;
- A 15% reduction in emissions of small particulates (PM_{2.5});
- A 27% reduction in volatile organic compound emissions;
- A 25% reduction in sulfur dioxide emissions.⁹⁴

A successful transition to electric vehicles will require additional action

No single policy is enough to bring about a full transition to electric vehicles, although a strong ZEV program would have the most meaningful impact. To support Pennsylvania’s transition to electric vehicles, the commonwealth should implement the following:

Photo: Joe & Kathy on Flickr



Solar EV charger at Park City Mall in Lancaster.

- **Expanded EV charging infrastructure**, so that Pennsylvanians can be confident that they can travel freely around the commonwealth without fear of running out of charge.
- **Lead-by-example** efforts to deploy electric vehicles in government fleets, consistent with President Biden’s recent commitment to electrify the federal fleet.⁹⁵
- **Public education programs** to inform Pennsylvanians about the benefits of electric vehicles, the range of options available, and how to keep their vehicles charged.
- **Utility policy reforms** to allow utilities to participate constructively and responsibly in the deployment of electric vehicle infrastructure, help EVs work optimally with the grid, and ensure that consumers benefit financially from EV adoption through fair rate designs.
- **Building code and zoning code** amendments to require the addition of EV charging capability in new homes and at commercial establishments.
- **Targeted efforts to overcome barriers to EV ownership and use** among residents of multi-family buildings, low-income residents and private fleets.

In addition, the state should move to electrify medium- and heavy-duty vehicles, continuing the commonwealth’s transition away from fossil fuels for transportation.

The ZEV program is a proven and powerful policy that Pennsylvania can adopt to hasten the transition to electric vehicles. Pennsylvania should join the 13 other states that have adopted the ZEV program.

Conclusion and recommendations

To meet its climate goals, improve air quality and get off fossil fuels for transportation, Pennsylvania should transition to zero-emission electric vehicles as quickly as possible. The commonwealth has laid the groundwork for an ambitious effort to clean up its transportation sector. By adopting the Zero-Emission Vehicle program and other policies to spur electric vehicle adoption, Pennsylvania can make good on its climate promises, clear our air, and put technologically advanced clean vehicles in the hands of millions of Pennsylvanians.

Pennsylvania should move to adopt the Zero-Emission Vehicle program and take other actions to support the transition to electric vehicles, including:

- Expanding Governor Wolf's climate change executive order with more ambitious ZEV targets for the state fleet, including 50% ZEVs by 2030 and 100% ZEVs by 2035.⁹⁶
- Increasing rebates for ZEV purchases.
- Adopting EV-ready building code amendments to ensure that new homes and commercial buildings are equipped for EV charging.
- Passing a planning bill to support and expand EV infrastructure.
- Developing education and outreach efforts for consumers and dealers to raise awareness of EV technology and available incentives.
- Providing technical assistance and resources for fleet managers looking to electrify their fleets.
- Collaborating with utilities to ensure that EVs are integrated in a way that optimizes the grid.
- Joining the Transportation and Climate Initiative Program and collaborating with other states in the region to limit transportation emissions.
- Implementing other recommendations in Pennsylvania's Electric Vehicle Roadmap that can accelerate and ease the integration of electric vehicles into the commonwealth's transportation system.

Methodology

This report estimates vehicle emissions of carbon dioxide pollution under a reference case scenario and under a ZEV policy scenario in which Pennsylvania adopts a version of the Zero-Emission Vehicle program consistent with achieving 100% zero-emission vehicle sales in 2035 and thereafter.

The findings are derived from a spreadsheet model that reflects assumptions about program stringency, fleet composition, fuel economy, vehicle age, vehicle-miles traveled (VMT) accumulation by vehicle age, carbon content of fuel and other factors.

For each year, fuel consumption is estimated for both cases in eight categories:

- Gasoline-powered cars
- Gasoline-powered light trucks
- Electric cars
- Electric light trucks
- Plug-in hybrid cars – gasoline consumption
- Plug-in hybrid cars – electricity consumption
- Plug-in hybrid trucks – gasoline consumption
- Plug-in hybrid trucks – electricity consumption

In each category and for each year, the analysis begins by estimating the number of vehicles of each model year that are on the road in any given year, and then multiplying by the average number of VMT estimated to be traveled by vehicles of that type and age. These model year-specific VMT estimates are then multiplied by the estimated fuel economy of vehicles of that

type and model year to arrive at an estimate of fuel consumption. Fuel consumption estimates are then summed across all model years of vehicles on the road in a particular year to develop an estimate of annual fuel consumption of vehicles of that class. These fuel consumption estimates are then multiplied by estimates of the amount of carbon dioxide produced by burning a unit of fuel to arrive at an estimate of carbon dioxide emissions from light-duty cars and trucks in that year.

Fleet characterization

A simplified characterization of the Pennsylvania light-duty fleet was developed based on the U.S. Energy Information Administration's 2020 Annual Energy Outlook (AEO)⁹⁷ and Pennsylvania vehicle registration data from the Auto Alliance.⁹⁸ Only vehicles in the categories listed above – cars, light trucks and plug-in hybrids – were included in the analysis. Vans, which span the light-duty and medium-duty categories, were excluded, as were vehicles running on alternative fuels such as propane, natural gas and hydrogen. Gasoline and diesel hybrids and ethanol flex-fuel vehicles were counted as conventional, gasoline-powered vehicles. Crossovers, SUVs and pickups were categorized as light trucks.

Fleet size and composition across the car/light truck categories were held constant throughout the modeling period.

The proportions of gasoline-powered, electric and plug-in hybrid vehicles for each model year in the two scenarios was determined as follows:

- For model years 2012-2019, the number of electric vehicle sales in Pennsylvania was obtained from the Auto Alliance Advanced Technology Vehicle Sales Dashboard.⁹⁹ No electric light-duty trucks were assumed to have been sold in Pennsylvania prior to model year 2020.
- For model year 2020 and subsequent years in the reference case, proportions of conventional, plug-in hybrid and electric vehicle sales were based on reference case projections in *Annual Energy Outlook 2020*.¹⁰⁰
- The gasoline-powered cars and trucks category included vehicles in the gasoline internal combustion engine, TDI diesel, ethanol flex fuel, electric-gasoline hybrid, and electric-diesel hybrid categories in AEO 2020.
- The electric vehicle category included pure electric vehicles of all ranges.
- The plug-in hybrid category included plug-in hybrids of all all-electric ranges.
- Vehicles powered by other alternative fuels were excluded.
- In the ZEV policy case, electric vehicle sales were projected to increase linearly, in both the car and light truck categories, to reach 100% of light-duty vehicle sales in 2035. This is based on the assumption that post-2025 ZEV program rules will be consistent with a pathway to 100% electric vehicle sales by 2035 across both the car and light truck categories. (See Figure 5.)

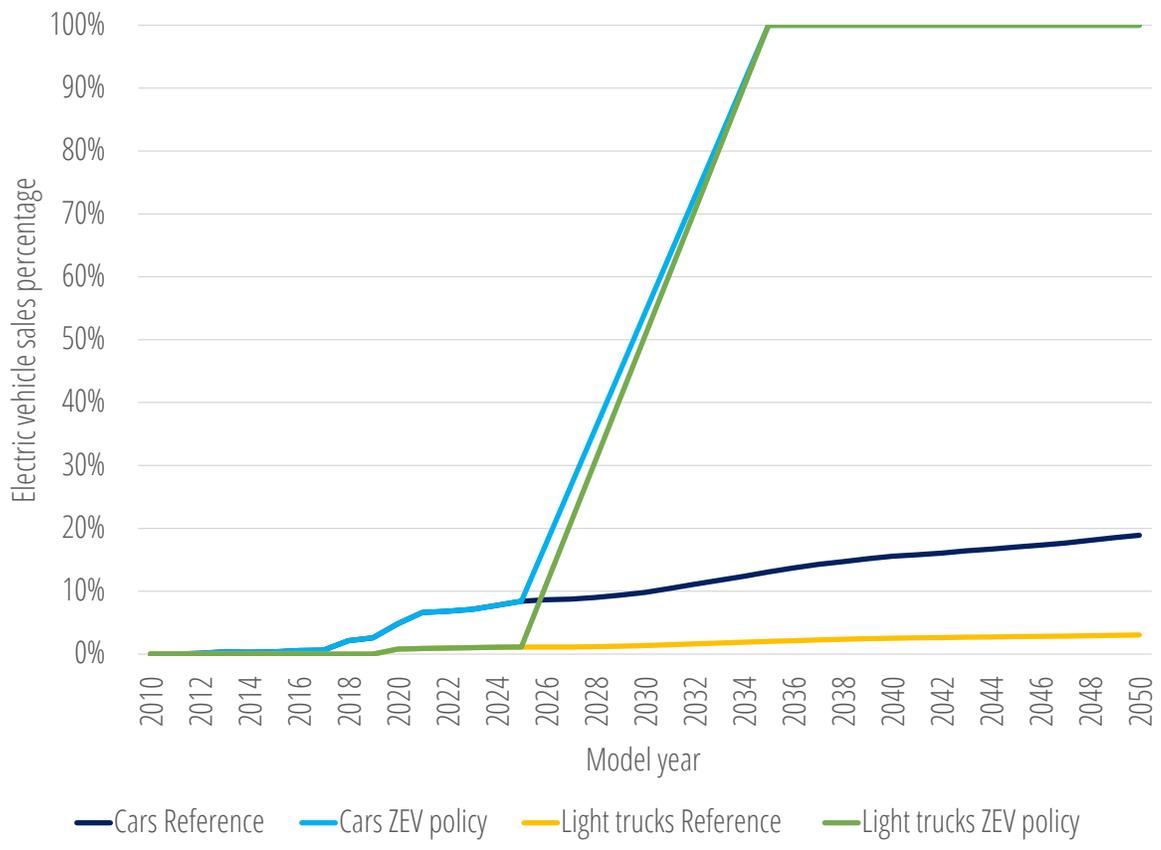


Figure 5. Electric vehicle sales percentages in reference and ZEV policy cases

- The percentage of plug-in hybrid vehicle sales for each year in the reference case is assumed to be consistent with AEO 2020 projections. In the ZEV policy case, plug-in hybrid vehicle sales are assumed to trend toward zero during the 2030-2035 period as zero-emission vehicles make up an increasing share of the vehicle fleet. The trajectory of plug-in hybrid sales in the ZEV policy case will depend critically upon the structure of the ZEV program and its treatment of credits for “Transitional ZEVs” (TZEVs) between 2025 to 2035. Should California continue to require steady or increasing sales of TZEVs during that period, this analysis will tend to underestimate their impacts on fuel consumption of the fleet.

The distribution of vehicles by age was derived from the Environmental Protection Agency’s Motor Vehicle Emission Simulator (MOVES) vehicle age distribution table.¹⁰¹ These vehicle age distributions were used to determine the number of vehicles of each type and model year that were on the road in each year.

VMT accumulation

Vehicles of each age were assumed to accumulate VMT based on data from the Federal Highway Administration’s 2017 National Household Travel Survey for mean annual VMT per vehicle by age and vehicle type.¹⁰² Conventional truck VMT were calculated by independently weighting pickup trucks and SUVs based on sales data from Auto Alliance with crossover vehicles counted in the latter category. VMT accumulation rates were assumed to be the same for electric, plug-in hybrid and conventional vehicles of each type.

The split between electric and gas-powered VMT for plug-in hybrid vehicles was based on research on real-world driving patterns prepared for the California Air Resources Board (CARB) by the UC Davis Plug-in Hybrid & Electric Vehicle Research Center in 2017.¹⁰³ The 2015 Toyota Prius Plug-in Hybrid was used as reference for 10-mile PHEVs while the 2015 and 2016 Chevrolet Volts were used as reference for 40-mile

PHEVs.¹⁰⁴ 10- and 40-mile electric PHEVs were analyzed independently and weighted based on projected vehicle counts.

Note that the VMT accumulation estimates referenced above are based on national figures from the National Highway Traffic Safety Administration. No parallel data accounting for driving patterns in Pennsylvania are available. However, per-capita VMT in Pennsylvania is roughly 20% below the national average, according to the Federal Highway Administration’s Highway Statistics reports.¹⁰⁵ The adjustment factor for this model reflects that ratio and was derived by dividing the Federal Highway Administration’s 2019 Pennsylvania VMT by the unadjusted total VMT produced by the model. This adjustment for reduced VMT in Pennsylvania was applied at the end of the analysis (see below) and assumes a proportional reduction in VMT across all classes and model years of vehicles.

Fuel economy

The analysis above produced estimates of the number of miles traveled by vehicles of a particular age and type and, in the case of plug-in hybrids, the amount of VMT traveled on electricity versus gasoline. These VMT estimates were then multiplied by fuel economy estimates/projections to arrive at the amount of fuel consumed by each vehicle age and type for each year.

- Gasoline vehicle fuel economy for model years up to and including 2020 was based on real-world historical data from the 2020 EPA *Automotive Trends Report*.¹⁰⁶ For model years after 2020, gasoline vehicle fuel economy projections were based on CARB’s 2020 Framework Agreement for Clean Cars and assumed an annual 3.7% fuel efficiency increase for model years 2022-2026 followed by a plateau.¹⁰⁷
- Electric vehicle fuel economy was based on miles per gasoline gallon equivalent forecasts averaged across weighted sales projections for 100-mile, 200-mile and 300-mile range EVs from AEO 2020. 2020 EV fuel economy was used for EVs from 2012-2019.

- PHEV fuel efficiency was based on 2019 model data from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.¹⁰⁸ PHEV trucks were assumed to have a gasoline fuel efficiency of half of their PHEV car counterparts based on projected vehicle weights.

Carbon intensity of fuels

Carbon dioxide emitted per gallon of gasoline burned was obtained from the U.S. EPA.¹⁰⁹ Carbon dioxide emissions per kilowatt-hour of electricity consumed from the Pennsylvania electric grid were based on reference case projections from AEO 2020.¹¹⁰ Electricity sales and carbon emissions for the eastern and western regions of the PJM interconnection were weighted 75% and 25%, respectively, based on PJM's estimation of the relative split in Pennsylvania energy consumption between 2017 and 2019.¹¹¹

VMT adjustment

As noted above, carbon dioxide emissions estimates were adjusted downward by approximately 19.5% based on the difference between the FHWA's 2019 Pennsylvania VMT and the model's unadjusted 2020 VMT. Per-capita VMT for Pennsylvania and the United States as a whole were based on data for 2019 from the U.S. Census Bureau and the Federal Highway Administration.¹¹²

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