

S. HRG. 118–45

CLEANER VEHICLES: GOOD FOR CONSUMERS AND PUBLIC HEALTH

HEARING

BEFORE THE

SUBCOMMITTEE ON CLEAN AIR,
CLIMATE, AND NUCLEAR SAFETY

OF THE

COMMITTEE ON
ENVIRONMENT AND PUBLIC WORKS

UNITED STATES SENATE

ONE HUNDRED EIGHTEENTH CONGRESS

FIRST SESSION

APRIL 18, 2023

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COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

ONE HUNDRED EIGHTEENTH CONGRESS

FIRST SESSION

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CLEANER VEHICLES: GOOD FOR CONSUMERS AND PUBLIC HEALTH

TUESDAY, APRIL 18, 2023

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON CLEAN AIR, CLIMATE, AND NUCLEAR
SAFETY,
Washington, DC.

U.S. Senate Committee on Environment and Public Works Subcommittee on Clean Air, Climate, and Nuclear Safety Washington, DC.

The committee, met, pursuant to notice, at 2:36 p.m. in room 406, Dirksen Senate Office Building, Hon. Edward J. Markey (chairman of the subcommittee) presiding.

Present: Senators Markey, Ricketts, Carper, Merkley, Padilla, Capito, Cramer, Lummis, Sullivan.

OPENING STATEMENT OF HON. EDWARD J. MARKEY, U.S. SENATOR FROM THE STATE OF MASSACHUSETTS

Senator MARKEY. Good morning. I call the Subcommittee on Clean Air, Climate, and Nuclear Safety to order for this important hearing on vehicle emissions standards and clean vehicles.

Thank you to my Ranking Member, Senator Ricketts, and to the Chairman and Ranking Member of the Committee on Environment and Public Works, Senator Carper and Senator Capito, for their helpful partnership in holding this very timely hearing.

It is my pleasure to welcome my colleagues on the subcommittee, as well as our three witnesses. We appreciate your willingness to appear before our subcommittee today because, one day after Massachusetts celebrated Patriot's Day, we are here to discuss America's clean energy revolution, which is already well underway.

Last week, the Environmental Protection Agency (EPA) proposed historic new rules to strengthen vehicle emissions standards for cars and for trucks. Thanks to the Bipartisan Infrastructure Law (BIL), the CHIPS and Science Act, and the Inflation Reduction Act (IRA), we can be more ambitious in our standards than ever before because we are actively building a world in which we can meet and exceed those goals.

Because of those bills, more than \$135 billion will be invested to build America's electric vehicle future. We have unleashed incentives for clean cars and trucks while creating new American jobs in the process. We are putting billions of dollars toward new electric vehicles' charging stations, which will make clean cars an option for families across our Country.

We are making clean vehicles more affordable. We are making them more accessible, and we are making them here in the United States. Companies are racing to take part in this revolution, announcing over \$100 billion in battery investments alone.

While we buildup our electric vehicle supply chain in the United States, we need roadside assistance for the remaining gas-guzzling cars and trucks on the roads to help fight climate change, save drivers money, and protect public health. That is where the EPA has to step in.

Transportation emissions make up 27 percent of total greenhouse gas emissions in the United States, more than half of which comes from light duty vehicles, and a quarter of which comes from heavy duty vehicles and trucks. Cars and trucks also produce nitrogen oxides and other toxic pollution that increases asthma and cancer rates, harming public health and disproportionately affecting Black, Brown, and indigenous communities.

To keep moving down the road to a safer, healthier, and more affordable future, we need strong greenhouse gas emission and multi-pollutant regulation for light duty and heavy-duty vehicles, we need a foot not on the gas, but on the accelerator. Those benefits are a bonanza of benefits to our climate, to drivers, and to our health. We need to make sure they also benefit union American workers.

First, EPA's proposed rule for light duty vehicles for model year 2027 through at least 2032 would reduce carbon dioxide emissions from light duty vehicles by more than half compared to existing standards. EPA estimates that the Light and Medium Duty Rule could one, provide up to \$1.6 trillion in net benefits through the lifetime of covered vehicles, avoid 7.3 billion metric tons of carbon dioxide over 2027 to 2055, and save drivers up to \$13,000 apiece in fuel savings and maintenance costs.

Additionally, the EPA projects that 60 percent of new light duty vehicles sold by 2030 will be electric as a result of the proposed rule, overtaking President Biden's target for 50 percent of new vehicle sales to be electric by 2030.

The Light Duty Rule could be expanded upon, and I am interested to hear from our witnesses about what they recommend, but even so, it is an incredible start. The Heavy Duty Rule also makes progress and charts a new course for American industry, but we still need to make sure the Heavy Duty Rule does not stall out our efforts to regulate other pollutants like smog and particulate matter from trucks and other big vehicles.

EPA projects that its Heavy Duty Rule will avoid 1.8 billion tons of carbon dioxide emissions by 2055, provide net benefits of up to 350 billion through 2055, provide 12 billion in reduced reliance on oil imports, and result in a 50 percent zero-emissions vehicle penetration rate of vocational vehicles. Strong proposed regulations are critical to driving climate progress forward, but they are more doable than ever, thanks to the billions in clean vehicles investments passed by Congress.

As our expert witnesses will explain, the clean vehicles revolution is not in our rearview mirror. It is right in front of us.

Before we hear from our witnesses, and we thank you so much for joining us today, I want to turn for an opening statement from our Ranking Member, Senator Ricketts.

**OPENING STATEMENT OF HON. PETE RICKETTS,
U.S. SENATOR FROM THE STATE OF NEBRASKA**

Senator RICKETTS. Thank you very much, Mr. Chairman.

As we all know, last week, the EPA introduced or announced burdensome new regulations on emission requirements for American-made vehicles, including both light cars and heavy-duty trucks. These detached-from-reality requirements are going to have a disastrous impact on the well-being of American families, American drivers, and American businesses.

Rules like this tell States like mine that the EPA and Washington, DC. does not care about our quality of life and does not understand who we are. It restricts freedom, shrugs off the higher cost of electric vehicles while families are struggling, ignores supply chain and infrastructure challenges, and disregards a better solution like American biofuels like ethanol.

This rulemaking claims to be technology-neutral while simultaneously touting on about the push toward the Administration's goal of an entirely electric vehicle America. Let us not forget the average cost of electric vehicles is around \$65,000. That is about 33 percent, or a third higher, than the average cost of a car right now. Frankly, that is more than most American households' income. In Nebraska, you are basically asking the average family to spend their entire year's income on buying this car. This Administration wants to take Nebraska families' entire income to do that.

As far as the claims that this rule will lower carbon emissions, the increased costs will actually have the opposite impact, because when you increase the cost of the average vehicle because you are going to drive this mandate for electric vehicles, that means new and used vehicles will become more expensive, which means people are going to hold on to them longer before being able to purchase a new vehicle, and that means that you are going to have more emissions.

The EPA mandate also fails to address the many logistics challenges that come from a massive switch to EVs and what it poses. America lacks sufficient EV charging stations to cover the sharp increase in demand. President Biden's own Department of Energy map in the northern part of Nebraska shows no EV chargers on a 340-mile stretch of U.S. Highway 20 from Allen to Hay Springs. Many Nebraska communities are hundreds of miles from the nearest charging station.

I hail from the Beef State, and I can guarantee you that electric trucks are really not practical when you are hauling livestock. You can not just pull over on the side of the road to charge for two hours when you are hauling a truckload of cattle in 90-degree heat. It does not work that way. It is just not feasible.

In tandem with these rulemakings, President Biden has refused to support American energy production, going after traditional power plants, canceling lease sales, and refusing to expedite permits for new construction. Instead of developing our national re-

sources, his policies are increasing our reliance on foreign adversaries.

The American Transportation Research Institute (ATRI) says that full electrification of the U.S. vehicle fleet would utilize a large percentage of the Country's current electric generation capacity. Domestic long-haul trucking would use more than 10 percent of the electricity generated in our Country today, while an electric U.S. fleet would use more than 40 percent. This will cause an incredible strain on the electric grid at a time when the Biden Administration is dragging its feet on permitting generation, transmission, and storage of energy of all types.

While I am all for renewable energy production, and trust me, electric cars are cool. They have great torque, accelerate fast, that is cool stuff, this Administration is brushing over the need for reliable, baseload generation. Not to mention the fact that consumers paid 14.3 percent more for electricity last year on average than in 2021, more than double the overall 6.5 percent rise in prices. This is according to the Consumer Price Index data released at the beginning of this year.

ATRI's analysis also found that tens of millions of tons of cobalt, graphite, lithium, and nickel will be needed to replace the existing U.S. fleet with battery electric vehicles, placing high demand on raw materials. For some materials, electrification of the U.S. vehicle fleet would require almost 35 years of the current global output.

According to the U.S. Geological Survey, the Chinese Communist Party controls around 80 percent of the world's production of rare earth elements, including elements like graphite and neodymium that are used in EVs. President Biden's own Defense Department concluded in 2021 that an overreliance on the Chinese Communist Party creates risk of disruption and politicized trade practices, yet his EPA is moving forward with a mandate that will increase this risk.

The Biden Administration has also excluded liquid fuels, which support jobs in rural communities across our Country. In Nebraska, we produce affordable, reliable, and clean-burning ethanol and biodiesel. Renewable fuels are a here and now technology proven to work in heavy duty vehicles.

Right here in D.C., for example, the garbage and recycling trucks operate on pure biodiesel, a fuel produced from waste fats and oils. Just last month, a poll showed that 70 percent of the poll responders support increasing the availability of E15 to help lower fuel prices and support energy independence. That same poll shows that responders strongly oppose government mandates related to their vehicle purchase options.

A bipartisan coalition of farm State Senators has long worked to promote renewable fuels, a tried-and-true technology for which the infrastructure already exists today, lowers carbon footprints, and saves consumers money at the pump, all while supporting our communities in rural America.

There are many steps that we can take to support this here and now solution, and we must adopt a fair and consistent emissions model to truly compare these fuel sources apples to apples.

In short, emissions reductions technology should be consumer-driven, economically viable, and operate on a level playing field for

all technologies. I am exploring options to push back on this Administration's overreach. I look forward to discussing these issues with our panel of witnesses. Thank you all for attending today.

I would also like to ask unanimous consent to submit four letters that I have here from the American Truck Dealers, Growth Energy, Renewable Fuels Nebraska, and the Renewable Fuels Association.

Senator MARKEY. Without objection, so ordered.

[The referenced information follows:]



**Statement of the American Truck Dealers
412 First Street SE, First Floor
Washington, DC 20003
(202) 547-5500**

**Submitted for the Hearing Record
“Cleaner Vehicles: Good for Consumers and Public Health”
U.S. Senate Committee on Environment and Public Works
April 18, 2023**

Chairman Carper and Ranking Member Capito, the American Truck Dealers (ATD), a division of the National Automobile Dealers Association, appreciates the opportunity to submit comments for the record. Our comments will highlight the U.S. Environmental Protection Agency’s (EPA) final rule entitled “Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards,” as Congress seeks to better understand the impacts of these stringent new federal emissions standards. ATD represents over 1,800 franchised commercial truck dealerships who employ more than 144,000 people nationwide. Recently, ATD helped launch the Clean Freight Coalition, an alliance of truck transportation stakeholders committed to a clean energy future.¹

In March 2022, EPA published a proposal to implement the Cleaner Trucks Initiative (CTI), first announced in November 2018.² Among other things, the CTI aimed to update current 2010 heavy-duty on-road engine (HDE) oxides of nitrogen (NOx) emission standards, increase the stringency of the existing Phase 3 greenhouse gas (GHG) mandates, streamline certain HDE emissions testing and certification procedures, and establish strategies to enhance long-term in-use emission performance.

The American trucking industry, which has an essential role in the economy, has made tremendous progress in reducing emissions and protecting the environment as it continues its efforts to reduce greenhouse gas emissions from freight transportation.³ Our statement focuses on EPA’s final heavy-duty engine rule and serious concerns regarding its potential impacts on commercial motor vehicle (CMV) sales, fleet turnover, and affordability and reliability of the truck CMV market. Implications regarding EPA’s recent proposal entitled “Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles – Phase 3” are also highlighted.

¹The Clean Freight Coalition is a comprised of truck dealers, motor carriers of every size and sector and truck manufacturers. The coalition aims to educate policymakers regarding the facts on how clean and green today’s new trucks are and the need for sound policies that lead to deployment of these new trucks that also assures affordable and reliable freight transportation and protects the nation’s supply chain. There are five official members of the Clean Freight Coalition: the American Truck Dealers, the American Trucking Associations, National Tank Truck Carriers, the Truck & Engine Manufacturers Association, and the Truckload Carriers Association.

² 87 Fed. Reg. 17414, *et seq.* (March 28, 2022). In August 2021, the CTI was folded into a Clean Truck Plan which also aims to set new CMV greenhouse gas (GHG) standards for model years 2030 and beyond.

³ See [Clean Freight Coalition, “Our Progress.”](#)

Background

America's truck dealers have long supported emission improvements for HDEs. However, any new emissions mandates such as EPA's NOx rule, must not compromise the affordability, reliability, fuel economy, and/or serviceability of HDEs and CMVs. If a final rule has some or all these attributes, prospective customers will avoid purchasing or leasing new CMVs, which have too high of a cost, offer performance compromises, or pose risks of unacceptable downtime. Government policies that have not provided sufficient lead time or regulatory stability have proven ineffective and harmful, as described below. The committee should keep in mind that CMVs are purchased or leased only to meet the business needs of their customers, and that they are customizable and specifically built to accomplish a variety of jobs and specific tasks.

Largest Expected "Pre-Buy/No-Buy" Will Significantly Disrupt the Truck Market

When EPA implemented their model year (MY) 2004-2010 emissions mandates, it directly resulted in higher truck prices, increased operating costs, reduced reliability, and lower fuel economy performance, which caused dramatic disruptions to the new truck marketplace. As a result, many prospective new truck purchasers rushed to "pre-buy" trucks with pre-compliant technologies to avoid the effects of EPA's costly mandates. A surge of orders came in for pre-MY 2007 equipment followed by a significant drop in orders. The reaction that resulted in the marketplace was to avoid higher prices and poorer performance of compliant technologies.⁴

In December 2022, the EPA finalized the "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards" rule, which could potentially set the stage for a repeat of what manifested in 2005-2007. Beginning with MY 2027 CMVs, the final rule calls for NOx emissions to be reduced 0.035 grams per horsepower-hour during normal operation, 0.05 grams at low load, and 10 grams at idle. Ultimately, the rule aims to reduce the remaining 1-2% of tailpipe NOx emissions for 2027 and later CMVs by 82.5%.

In response to EPA's rule, a massive "pre-buy/no-buy" is anticipated to start leading up to 2027. ACT Research analyzed EPA's heavy-duty engine rule and its likely impact on the U.S. truck manufacturing and freight transportation industries. According to Kenny Vieth, president and senior analyst at ACT Research, the new standards will likely result in the largest truck pre-buy ever, beginning sometime in 2025 or 2026. Vieth stated, "what makes 2027 different is that instead of price increases driven by new systems, components or technology, the main hit for fleets will come on the warranty front. What will be new are significant, mandated, warranty extensions on emissions control systems. Those systems will likely go from today's two years/250,000 miles to 400,000 miles in 2027 and topping out at 600,000 in 2031."⁵ Besides the technology advancements that will increase the price of a truck, taxes, fees, and warranty extensions will play a significant role in increases to the price of a truck.

A significant "pre-buy/no-buy" is the last thing the trucking industry wants because not only would environmental goals be delayed, but there could also be severe job loss and lay-offs in vehicle assembly plants, powertrain production facilities, and elsewhere.

⁴ The deleterious economic impacts of this rulemaking should serve as a cautionary tale for the recently finalized new NOx standards. In 2012, the National Automobile Dealers Association (NADA) issued "[A Look Back at EPA's Cost and Other Impact Projections for MY 2004-2010 Heavy-Duty Truck Emissions Standards](#)" by Esteban Plaza-Jennings et al. This retrospective study examined EPA's 2004-2010 heavy-duty truck emission rules and compared EPA's predicted compliance costs to actual OEM compliance costs. When put side by side, NADA found that EPA underestimated per vehicle costs of compliance by up to 320%. While EPA predicted vehicle prices would increase by \$5,000 per truck, the actual price increase was over \$21,000.

⁵ Jack Roberts, "[Is a Massive Prebuy Headed Toward Trucking?](#)" *MOTOR Information Systems*, (Oct. 13, 2022).

EPA's Mandates Delay Turnover of America's Truck Fleet

Truck buyers can expect EPA's final NOx rule to increase the price of a new heavy-duty truck by \$20,000 to \$25,000, according to Tim Denoyer, Vice President and Senior Analyst at ACT Research.⁶ When truck buyers are faced with higher truck pricing and lower truck performance, prospective new CMV customers hold onto their older equipment longer instead of buying new equipment.

This fact should concern the committee, as new trucks have made significant environmental gains due to recent federal emissions and fuel-economy mandates and industry innovation. For example, cleaner fuel and engines utilizing advanced technologies have combined to reduce NOx emissions and particulate matter (PM) emissions by 98% when compared to the late 1990s. To put that in perspective, it would take 60 new trucks to generate the same level of emissions as a single truck manufactured in 1988. From 2007 to 2020, new trucks have reduced carbon dioxide (CO₂) emissions by 202,000,000 tons, NOx emissions by 27,000,000 tons, and saved 472,000,000 barrels of crude oil.⁷

Nearly half of the Class 8 trucks on the road are over 10 years old. The primary reason trucks older than a decade are still on the road is the higher costs due to these regulatory mandates. Truck buyers and small businesses now hold onto their older trucks longer, or purchase used trucks, rather than investing in trucks with the latest environmental technologies. Stringent policies that delay the transition from older trucks to cleaner, greener trucks keeps older model year CMVs on the road and is counterproductive to meeting the environmental goals sought by EPA.

For example, during the last "pre-buy/no-buy" CMVs built prior to 2007 stayed on the road longer and the age of the Class 7 fleet increased to 6.6 years, about 11 months older than the historical average dating back to 1979. Additionally, because of this added costs, EPA's final NOx rule may inhibit the roll-out of important new accident-reducing features and systems such as advanced driver assistance systems (ADAS).

EPA's Useful Life & Warranty Changes Must be Modified to Ensure Market Viability

ATD supports reasonable revisions to existing HDE/CMV emissions warranty periods. The EPA's proposals acknowledged that longer emissions warranty periods are likely to increase the purchase price of new CMVs. In fact, of the \$20,000 to \$25,000 increase of the cost per truck, most of the increase would be due to warranty and useful life changes. The new rules increase the defined useful life of regulated vehicles by 1.5 to 2.5 times, from 435,000 miles to 635,000 miles. Emissions systems warranties will increase by 2.8 to 4.5 times, or from 100,000 miles to 450,000 miles for MY2027 trucks.

By definition, an emissions warranty is included in the price a first purchaser pays when buying a new CMV. However, given that CMV and HDE OEMs must "pass on" the costs associated with emissions warranty (and useful life) mandates, the practical result will be an increase above the prices first purchasers would otherwise pay for the new CMVs and HDEs they buy. ATD is also concerned that new CMV purchasers with short trade cycles will not value and want to "pay for" the incremental cost of lengthy emissions warranties.

⁶ Heavy Duty Trucking, Trucking Info, [EPA 2027 and Beyond: How Will New Low-NOx Rules Affect Fleets?](#) (March 16, 2023).

⁷ Heavy Duty Trucking, Trucking Info, [Analysis: Clean Diesel Truck Adoptions Jumping in Southwest, Northwest](#) (July 23, 2021).

Congressional Action on EPA's NOx Rule

On November 17, 2022, Sen. Joni Ernst (R-Iowa) and 16 Senators sent a [letter](#) to the EPA urging the agency to ensure its pending nitrogen oxide emissions rule is technologically achievable and affordable. On February 9, 2023, Sen. Deb Fischer (R-Neb.) and 33 Senators introduced legislation to overturn EPA's overly stringent and costly NOx emission rule. This resolution ([S.J. Res. 11](#)) was introduced under a procedure established by the Congressional Review Act (CRA).

EPA Issues Aggressive GHG Emissions Proposal for Heavy-Duty Vehicles

On April 13, 2023, the EPA issued a proposal entitled "Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles – Phase 3" aimed at dramatically reducing GHGs from new heavy-duty vehicles built and delivered for sale in MYs 2027-2032.

The 717-page proposal targets fleet-wide GHG reductions from MY 2027-2032 heavy-duty vocational and road tractor vehicles. It contains several compliance options, each of which contemplates that CMV manufacturers will bring to market a large number of battery, plug-in hybrid and fuel cell electric vehicles (EVs) for those model years, to the tune of between 34-46% of heavy-duty EVs in MY 2032 (versus today's sales of <2%).

ATD remains all-in on promoting the adoption of advanced technology trucks and EVs, and its dealers are making substantial investments in the tools, training and equipment necessary to facilitate extensive EV adoption. More broadly, ATD supports sound policies that increase fuel efficiency and reduce GHGs for America's trucks. New trucks that reduce GHG emissions must be affordable and reliable for CMV customers to buy them. ATD is currently reviewing this new rule and plans to submit formal comments to the EPA.

Additionally, the Committee should keep in mind that the costs of these new GHG mandates come close on the heels of the NOx rule's \$39 billion price tag. At some point, truck buyers, especially small trucking firms, are simply going to be priced out of the new truck market. We urge Congress to examine the ramifications and the unintended consequences associated with EPA moving forward with overly stringent regulations that create affordability and reliability issues for the customer and in the long run could slow fleet turnover.

Congress Should Revisit Taxing Clean Heavy-Duty Trucks

Unlike light duty vehicles, heavy-duty trucks and trailers are almost entirely made in North America. These trucks and trailers are designed, tested, and assembled across the United States. One policy change Congress can undertake to offset the additional regulatory costs of EPA's mandates would be repeal of the federal excise tax (FET) on heavy duty trucks. Congress imposes the 12% FET on the retail sale of most new heavy-duty trucks.

The investments in new technologies required to fulfill these new environmental and regulatory mandates have added nearly \$40,000 to the price of a new truck, and these regulatory costs are also subject to the FET. The FET can also add more than \$50,000 to the price of an electric or hydrogen fuel-cell truck, as these vehicles are already more than twice the price of internal combustion engine trucks. To put this tax in perspective, the \$45,000 subsidy to purchase clean heavy-duty trucks included in the Inflation Reduction Act would not pay for the FET the federal government levies.

In this way, the FET's demand-suppressing effect delays fleet turnover and deprives society of the benefits of environmental gains, as truck owners decide to hold onto their older less

environmentally clean and less fuel-efficient trucks for longer periods of time. While new commercial trucks and trailers are as clean and green as they have ever been, the FET has delayed the deployment of these trucks, and they are not reaching the road fast enough to fully realize the benefits of significantly improved environmental technologies.

To promote more clean trucks on the road and a swifter transition to a lower carbon future, Congress should stop taxing the sale of clean trucks and repeal the FET. ATD urges Congress to pass the bipartisan “Modern, Clean, and Safe Trucks Act of 2023” introduced in the House ([H.R. 1440](#)) by Reps. Doug LaMalfa (R-Calif.), Chris Pappas (D-N.H.), Darin LaHood (R-Ill.), and Earl Blumenauer (D-Ore.) and in the Senate ([S. 694](#)) by Sens. Todd Young (R-Ind.) and Ben Cardin (D-Md.). See attached issue brief.

ATD stands ready to work with Congress and the EPA to modernize and promote the transition to a cleaner greener American truck fleet. Thank you again for the opportunity to submit testimony.



Repeal the Federal Excise Tax on New Heavy-Duty Trucks – Cosponsor H.R. 1440/S. 694
Promote the Transition to a Cleaner, Greener and Safer Truck Fleet

ISSUE

Congress imposes a 12% federal excise tax (FET) on the retail sale of most new heavy-duty trucks. This tax depresses heavy-duty truck sales and delays the purchase of cleaner, safer and more fuel-efficient trucks. Truck manufacturing and assembly employment is significant in the U.S., and the FET negatively impacts American truck industry jobs. **Members of Congress are urged to cosponsor H.R. 1440/S. 694 to protect U.S. jobs, replace older trucks with newer and greener trucks and promote the adoption of advanced technology trucks.**

BACKGROUND

The FET on heavy-duty trucks was first imposed in 1917 to help pay for World War I. The 12% FET is the highest excise tax on a percentage basis that Congress levies on a product, often adding as much as \$22,000 to the price of a new heavy-duty truck. The tax is imposed on top of the nearly \$40,000 in recent federal emissions and fuel-economy mandates, which already make it harder for small businesses to afford a new truck.

With more than half of the Class 8 trucks on the road over 10 years old, truck buyers and small businesses now hold onto their older trucks longer, or purchase used trucks, rather than investing in the latest environmental and safety technologies. Repealing the FET would immediately help modernize the truck fleet by incentivizing the purchase of new trucks with the latest emission-reduction technology and crash avoidance advancements. While new commercial trucks and trailers are as clean and green as they have ever been, the FET has delayed the deployment of these trucks, and they are not reaching the road fast enough to fully realize the benefits of significantly improved environmental and safety technologies. For example, the FET can add more than \$50,000 to the price of an electric or hydrogen fuel-cell truck, as these vehicles are already more than twice the price of internal combustion engine trucks.

Additionally, the FET has been the most inconsistent source of revenue to the Highway Trust Fund (HTF) over the past 20 years. Because FET revenue is dependent on volatile annual truck sales, the tax has contributed to the overall instability of the HTF. To establish long-term stability for the HTF, the 12% FET should be replaced with a more consistent revenue source. The Modernize the Truck Fleet coalition is working to identify viable funding options to replace this burdensome tax with a more consistent and equitable revenue mechanism to modernize and fund the HTF.

KEY POINTS

- **FET repeal would immediately benefit the environment by replacing older trucks with cleaner and more fuel-efficient trucks.** While new trucks have made significant environmental gains, such as reducing nitrous oxide emissions by 97% and particulate matter emissions by 98%, the FET remains a costly barrier to the purchase of new trucks with the latest environmental technologies. (Fuel economy regulations for heavy duty trucks did not exist in 2010.) Half the Class 8 trucks on the road are over 10 years old and lack the markedly cleaner technologies and fuel efficiency gains of today's trucks.
- **The FET should be repealed and replaced with a more consistent revenue source to fund the HTF.** Since the FET is based on annual truck sales which can vary greatly, the tax has been the *most inconsistent HTF revenue source over the past 20 years* and contributes to the long-term instability of the HTF.
- **Repealing the FET would spur new truck sales and protect the 1.3 million U.S. manufacturing, supplier, dealership and heavy-duty trucking and trailer related jobs.** Modernize the Truck Fleet, a coalition of industry groups and state associations, backs FET repeal because it would support American workers in manufacturing and sales and drive the adoption of advanced technology trucks.

STATUS

Bill to repeal the FET have been introduced in the House (H.R. 1440) by Reps. LaMalfa (R-Calif.), Pappas (D-N.H.), LaHood (R-Ill.), and Blumenauer (D-Ore.) and in the Senate (S. 694) by Sens. Young (R-Ind.) and Cardin (D-Md.). *To promote the deployment of cleaner trucks and the transition to a lower carbon future, Members are urged to cosponsor H.R. 1440/S. 694.*



701 8th Street, NW, Suite 450, Washington, D.C. 20001
 PHONE 202.545.4000 FAX 202.545.4001

GrowthEnergy.org

April 18, 2023

The Honorable Ed Markey
 Chairman
 Subcommittee on Clean Air, Climate, and
 Nuclear Safety
 U.S. Senate Committee on Environment and
 Public Works
 Washington, DC 20510

The Honorable Pete Ricketts
 Ranking Member
 Subcommittee on Clean Air, Climate, and
 Nuclear Safety
 U.S. Senate Committee on Environment and
 Public Works
 Washington, DC 20510

Dear Chairman Markey and Ranking Member Ricketts,

Thank you for the opportunity to participate in the conversation on the extensive benefits of ethanol in the future of cleaner vehicles. Biofuels, like plant-based ethanol, are a homegrown, lower-carbon, and lower-cost fuel option available at the pump today. Growing the share of renewable biofuels in America's fuel supply is critical to achieving energy independence, reducing prices at the pump for consumers, and reducing emissions today.

Growth Energy is the world's largest association of biofuel producers representing 91 U.S. plants that produce nearly 9 billion gallons of cleaner-burning renewable fuel annually; 112 businesses associated with the production process; and tens of thousands of biofuel supporters across the country. Together, we are working to bring better and more affordable choices to the fuel pump, support the rural economy, and protect the environment for future generations.

Our innovative biorefineries, both big and small, are identifying ways to reduce carbon emissions beyond the reductions that ethanol already brings to fuel. As we have said previously, a primary solution for the liquid fuel supply is to increase the use of ethanol, from starch and cellulosic sources. According to recent data from Environmental Health and Engineering, today's ethanol reduces greenhouse gas emissions (GHG) by an average of 46 percent compared to gasoline and can provide even further GHG reductions with additional readily available technologies.¹ In the existing light duty fleet, higher ethanol blends can be immediately deployed to achieve GHG reductions, reduce harmful air toxins, and reduce consumer costs at the pump.

We urge the U.S. Environmental Protection Agency (EPA) to consider clear policies that recognize the realities of today's fuel market and examine how homegrown biofuels can immediately contribute to achieving GHG reductions. Today, nearly all gasoline across the U.S. is blended with 10 percent ethanol. E15, a blend consisting of 15 percent ethanol, has been approved for use by EPA in all passenger vehicles model year 2001 and newer — more than 96 percent of the vehicles on the road today — and it is now for sale at more than 3,000 locations in 31 states. In fact, last summer, E15 saved drivers as much as nearly \$1

per gallon at the pump compared to E10. That is meaningful consumer cost-savings that comes from a lower carbon fuel. Further, while a permanent solution that would allow E15 sales year-round remains an important necessity, we urge the EPA to act on a temporary, emergency RVP waiver as soon as possible to remedy current and expected supply challenges resulting from ongoing conflict in Ukraine.

However, EPA's recently proposed tailpipe emissions standards show a lack of imagination and ignore the reality that even by the most aggressive estimates, internal combustion engines will still occupy more than half of the light-duty vehicle marketplace by 2040. This proposal would constrict innovation and risk leaving millions of tons of carbon reductions on the table—setting us on a path towards eliminating any role for proven, emissions-reducing biofuel blends precisely when we should be embracing a strategy that supports multiple low carbon options.

In President Biden's own words, "you simply can't get to net-zero by 2050 without biofuels." By disregarding the contributions of low-carbon biofuels and biofuel blends like E15, the proposal puts a thumb on the scale for one technology at the expense of others, rather than giving automakers the flexibility to pursue innovative strategies for decarbonizing light-duty vehicles.

For the U.S. to meet its climate goals from the transportation sector, low carbon biofuels must be part of any strategy to drive emissions reductions. The proposed standards should drive the adoption of the greatest possible range of technologies and fuels—particularly those that support hundreds of thousands of American jobs.

Biofuels are a mainstay of any climate strategy. No other solution offers the same immediate climate benefits while also reducing emissions of particulate matter, carbon monoxide, and other smog-forming pollutants linked to cancer and other negative health outcomes. Lower-carbon biofuels will be vital to decarbonizing transportation for decades to come, and it is a mistake for EPA to ignore their track record of success and their unmatched ability to lower emissions right now, as well as in the coming decades.

Sincerely,



Emily Skor, CEO
Growth Energy



April 17, 2023

Dear Members of the EPW Subcommittee on Clean Air, Climate, and Nuclear,

I am submitting a letter regarding economic and environmental impacts of the federal vehicle greenhouse gas emissions standards and clean vehicle investments included in the *Inflation Reduction Act* and the *Infrastructure Investments and Jobs Act*."

I will address several general areas of interest and concern.

1) Biofuel is good for agriculture and the environment.

Agriculture is vital to Nebraska and the United States as a whole. Not only does Agriculture provide safe and nutritious food for American families, but the agricultural sector also accounts for roughly one-fifth of our nation's economy. Nebraska has some of the richest farmland in the nation and is the nation's second largest ethanol producer. The state's 24 ethanol plants have a total production capacity of more than 2 billion gallons annually. Combined, these plants use more than 750 million bushels of corn per year and produce more than 6 million tons of distillers grains, a high protein livestock feed. Ethanol plants continue to improve their efficiency and get more gallons of fuel out of the same volume of feedstock with less energy. Farmers continue to utilize fewer acres and resources to grow even more grain year after year and meet increased demand for meat and dairy products among the world's growing middle class. As a result of technologies and efficiencies, the percentage of grain devoted to ethanol is expected to decrease even further.

Ethanol is energy positive, which means that it produces more energy than we use to make it. In fact, ethanol reduces greenhouse gases by up to 43%, when compared to petroleum-based gasoline. To put that in perspective, the amount of ethanol used around the world each year equates to removing 20 million cars from the road.

Biofuels generate economic activity in Nebraska through agricultural feedstock production, biofuel production facilities, transportation and distribution, value-added products, rural development, and environmental benefits. The development and utilization of biofuels can contribute to economic growth, job creation, and sustainable development in Nebraska, benefiting both rural and urban communities and reducing our dependence on imported petroleum products.

Renewable fuels have several positive impacts on the transportation of agricultural goods including reliability, reducing greenhouse gas emissions, increased energy security, and rural economic development. Renewable fuels help reduce dependence on fossil fuels, which are subject to price fluctuations and geopolitical tensions. This can



enhance energy security in the agriculture sector, ensuring a stable and reliable supply of fuel for transportation. Producing renewable fuels also creates new economic opportunities in rural areas which stimulates local economies, creates jobs, and contributes to sustainable rural development, benefiting agricultural communities.

2) EV Technology is not adequate for food security.

Bio-fuels technology for tractor-trailers and agriculture equipment is being field tested and will be market ready in the very near future. Utilizing E98 fuel in existing fleets and equipment is a far more efficient and viable option than converting everything to electric power.

Electric vehicles are not ready for transporting goods on a large scale and would have negative impacts on the production and delivery of agricultural goods.

EV charging infrastructure, particularly for transportation fleets is all but non-existent in rural areas. Farming to produce food, fuel and fiber relies heavily on modern technology, is seasonal and weather dependent, and must happen swiftly and efficiently. Farmers cannot be waiting days and weeks for seed, fertilizer, feed, etc. I don't even have the ability at this time to calculate the additional number of trucks that would be needed for delivery of inputs due to the time it would take to charge batteries. I anticipate minimally 30% to 50% MORE trucks would be required to carry out equal deliveries of cropping inputs and harvest deliveries.

EVs typically have higher upfront costs compared to traditional vehicles, which would be a barrier to adoption for small and medium-sized farmers and transportation companies. The higher costs of purchasing EVs and installing charging infrastructure would negatively impact the financial viability of those forced to adapt EV use.

EVs rely on large batteries that require significant resources for production and disposal. The extraction of raw materials for EV batteries, such as lithium and cobalt, has environmental and social impacts, including habitat destruction and human rights issues in mining communities. Additionally, the disposal of EV batteries raises concerns about waste management and recycling.

While EVs do not produce tailpipe emissions, the electricity used to charge them is generated from various sources, including fossil fuels. Depending on the energy mix of a particular region, EVs may still indirectly contribute to greenhouse gas emissions and other air pollutants from electricity generation, which would negatively impact environmental benefits of EVs in the agriculture sector.

The adoption of EVs for agricultural transportation may face challenges related to charging infrastructure, upfront costs, battery production and disposal, and electricity



generation impacts. Careful consideration of these factors is necessary to ensure a sustainable and efficient transportation system for agricultural goods in the future.

3) Antiquated electric grid is incapable of handling large fleet EV charging.

Another important factor to consider is that the electrical grid is not ready for the transportation of goods. There are several charging infrastructure gaps, while biofuels are a viable option ready for use today.

The increased demand for electricity from widespread EV adoption, including for transportation, would strain the existing electrical grid infrastructure. EVs draw significant power from the grid when charging, and a large-scale adoption of EVs for transportation of goods would require additional grid capacity and load management measures to ensure reliable and uninterrupted power supply. Americans have come to expect nothing short of a reliable and uninterrupted supply of electricity!

Agricultural transportation often involves long-haul routes that may require charging at multiple locations along the way. Please consider how incredibly inefficient that would be! Specifically, there is a need for upgrades to the electrical grid, including transformers, substations, and distribution lines, to accommodate the increased demand for electricity. Coordinating the installation and management of charging infrastructure across different areas, including rural and remote regions, presents logistical and technical challenges, such as power distribution, grid connectivity, and coordination of utility companies, regulatory agencies, and other stakeholders.

Renewable energy sources that are strongly encouraged by federal administration and financial incentives, such as solar and wind, are intermittent and variable. This poses challenges for not only the reliable and consistent charging of EVs, but all activities requiring electricity. The availability of renewable energy may not always align with the charging needs of EVs used in transportation of agricultural goods, leading to potential supply-demand imbalances and grid stability concerns.

The failure of the electrical grid has significant impacts on aspects of modern society, including agriculture and the transportation of goods. As recently as February 2021, we experienced a major failure of the electric grid. This wreaked havoc from individual homes to major manufacturing businesses. Let's not place unnecessary additional burden on our electrical grid!

Some specific potential impacts of electrical grid failures on the transportation of agricultural goods include the disruption of transportation operations, reduced mobility, loss of refrigeration and other critical systems, economic losses and impact to food and fuel supply chains.

If the electrical grid fails, it will cripple the charging infrastructure for EVs used in the transportation of agricultural inputs and goods. This will result in delays or



interruptions in operations, affecting the timely delivery of agricultural products to markets, processing facilities, or other destinations.

Agricultural goods play a critical role in the global food supply chain, and disruptions in transportation due to electrical grid failures would be a preventable negative impact on the availability and affordability of food for consumers. Many agricultural goods, such as perishable produce or frozen products, require refrigeration or other critical systems powered by electricity during transportation, to maintain their quality and safety. A failure of the electrical grid would result in the loss of refrigeration or other essential services, leading to spoilage, waste, and financial losses.

Transportation disruptions and reduced mobility due to electrical grid failures would result in delays, spoilage, and increased costs, impacting the profitability and viability of the entire agriculture value chain. This would create yet one more situation where the government would have to step in with disaster assistance for a completely preventable situation!

In some cases, the failure of the electrical grid during transportation operations can pose safety risks, such as disruptions in traffic management systems, lighting, or other safety measures. This would increase the risk of accidents, injuries, and other safety incidents during the transportation of agricultural goods.

Biofuels remain the single most powerful tool we have that will immediately decarbonize transportation while delivering savings at the pump. We are grateful to Senator Ricketts and other rural champions for their ongoing efforts to unlock the full potential of biofuels to reach our climate and energy security goals. The latest oil production cuts in the Middle East only reinforce how important it is to shield American drivers from continued global uncertainty. With an ambitious IRA, and unrestricted access to higher blends like E15, we can deliver greater security and savings for working families. Biofuel provides consumers with real choice and savings at the pump, while strengthening our rural economy, lowering our carbon footprint, and delivering greater energy independence by requiring a modest but growing number of biofuels be blended into our nation's transportation fuel mix.

Sincerely,
Dawn Caldwell

Executive Director
Renewable Fuels Nebraska
dawnc@renewablefuelsne.org



April 17, 2023

Honorable Sen. Ed Markey
Chairman
Senate Environment & Public Works Comm.
Sub-Committee on Clean Air, Climate
and Nuclear Safety
255 Dirksen Senate Office Building
Washington, DC 20510

Honorable Sen. Pete Ricketts
Ranking Member
Senate Environment & Public Works Comm.
Sub-Committee on Clean Air, Climate
and Nuclear Safety
139 Russell Senate Office Building
Washington, DC 20510

Dear Chairman Markey and Ranking Member Ricketts,

As the Subcommittee on Clean Air, Climate, and Nuclear Safety prepares for its April 18, 2023, hearing on "Cleaner Vehicles: Good for Consumers and Public Health," the Renewable Fuels Association would like to share our thoughts on the important role that low-carbon renewable fuels like ethanol can play in cleaning up our nation's transportation sector.

As you know, the transportation sector is the leading contributor of greenhouse gas (GHG) emissions in the United States, as well as a significant source of pollutants linked to poor air quality and human health concerns. Although GHG emissions from the transportation sector have declined slightly after peaking in 2006, the pace of emissions reduction must rapidly accelerate if the nation is to meet the ambitious goal of achieving net zero GHG emissions by 2050.

Achieving these emissions goals will require a broad and diverse portfolio of vehicle and fuel technologies. As the Subcommittee considers future strategies for reducing carbon emissions from vehicles and fuels, we believe it should avoid policy concepts that pre-determine technology winners and losers. Focusing on only one technology pathway or course of action for reducing transportation emissions would be shortsighted; if that course of action would happen to fail, American consumers and our environment would suffer the consequences. Under a technology-neutral policy approach to emissions reduction, the marketplace would determine the optimal combination of low-carbon fuels and vehicle technologies to achieve the goals that are best for consumers and public health.

We encourage the Subcommittee to remember this simple fact: **We can't have clean vehicles without clean fuels.** Fuels and vehicles operate as integrated systems; examining the carbon impacts of one in isolation of the other leads to distorted and flawed comparisons. For example, the

carbon footprint of certain battery electric vehicles operating on fossil-fuel generated electricity is no smaller—and can sometimes be larger—than the carbon footprint of modern internal combustion engine vehicles operating on today's ethanol-blended liquid fuels. It should not be assumed that an electric vehicle is a "clean vehicle" or a "zero emissions vehicle" simply because it does not have a tailpipe. The full range of emissions impacts related to producing, transporting, and using vehicle fuels must be considered when examining the overall carbon footprint of a certain vehicle/fuel technology pathway.¹

When the full carbon emissions lifecycle of all fuels is examined fairly, it becomes quickly obvious that low-carbon renewable fuels like ethanol offer an effective and immediate solution for reducing carbon emissions from liquid fuels across all segments of the transportation sector. Today's corn-based ethanol already cuts GHG emissions by approximately 50 percent, on average, compared to gasoline. According to the Department of Energy's Argonne National Laboratory, typical corn ethanol provides a 44 percent GHG savings compared to gasoline, even when unverifiable emissions from direct and indirect changes in land cover/land use are included.² When corn ethanol is compared directly to gasoline (i.e., no indirect emissions included for either fuel), Argonne National Laboratory finds that corn ethanol reduces GHG emissions by 52 percent, on average, versus gasoline. Similarly, researchers affiliated with Harvard University, MIT, and Tufts University concluded that today's corn ethanol offers an average GHG reduction of 46 percent versus gasoline.³

In addition, the California Air Resources Board (CARB) has conducted analysis and certified that ethanol produced from the cellulosic biomass found in corn generally reduces GHG emissions by 70-80 percent compared to gasoline; more than 140 million gallons of ethanol from cellulosic biomass was used in California in 2021.⁴ Overall, CARB found that from 2011 to 2021, the use of ethanol from all feedstocks cut GHG emissions from the California transportation sector by 31 million MT CO₂e, more than any other fuel used to meet the state's Low Carbon Fuel Standard requirements.⁵

¹ For a simple explanation of lifecycle ("well to wheels") carbon analysis and a carbon intensity comparison of ethanol, gasoline, and electricity for electric vehicles, see Cooper, G. (2022), The Truth About Ethanol and Carbon Emissions. <https://ethanolrfa.org/media-and-news/category/blog/article/2022/10/the-truth-about-ethanol-and-carbon-emissions>

² Lee, U., Kwon, H., Wu, M. and Wang, M. (2021), Retrospective analysis of the U.S. corn ethanol industry for 2005–2019: implications for greenhouse gas emission reductions. *Biofuels, Bioprod. Bioref.*, 15: 1318–1331. <https://doi.org/10.1002/bbb.2225>

³ Melissa J Scully *et al* (2021), Carbon intensity of corn ethanol in the United States: state of the science. *Environ. Res. Lett.* 16 043001. <https://iopscience.iop.org/article/10.1088/1748-9326/abde08>

⁴ CARB. "LCFS Pathway Certified Carbon Intensities." Viewed Feb. 7, 2023.

<https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities>

⁵ CARB. "Low Carbon Fuel Standard Reporting Tool Quarterly Summaries." Viewed Jan. 20, 2023.

<https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summaries>

With the increased adoption of low-carbon farming practices, Carbon Capture Utilization and Storage (CCUS), and other technologies, the U.S. ethanol industry is well on its way to producing zero-carbon corn ethanol. In fact, in a July 2021 letter to President Biden, RFA's member companies pledged that ethanol will achieve a 70 percent GHG reduction, on average, compared to gasoline by 2030 and a net-zero carbon footprint by 2050 or sooner.⁶

While ethanol's use historically has been as a motor fuel for light-duty vehicles, new innovations and emerging technologies are underscoring ethanol's carbon reduction benefits across *all* segments of the transportation sector, including light-, medium-, and heavy-duty vehicles; the marine sector; and even the aviation sector, through the utilization of ethanol as a feedstock in the production of sustainable aviation fuels (SAF).

But for this vision to become a reality, the biofuels industry needs smart policy and regulations for cleaner vehicles and fuels, including:

- use of the same carbon footprint boundaries for all fuels and vehicles;
- fairness and consistency in the methodologies used for measuring the carbon footprint of different fuels and vehicles;
- removal of unnecessary regulatory barriers that are blocking the use of fuel blends that contain higher levels of low-carbon ethanol, such as 15 percent blends (E15);
- continued investment in storage and distribution infrastructure for higher ethanol blends like E15 and flex fuels like E85;
- equitable incentives for the production of all cleaner vehicle technologies, including flex-fuel vehicles that can operate on fuels containing up to 85 percent ethanol.

Unfortunately, EPA's recently proposed *Multi-Pollutant Emissions Standards for Model years 2027 and Later Light-Duty and Medium-Duty Vehicles* **does not** take a technology-neutral approach to stimulating production of "clean vehicles."⁷ Instead, if finalized as proposed, the regulation would establish a de facto mandate for electric vehicles. This is due to the fact that the proposed regulation ignores the upstream carbon emissions and environmental impacts of electric vehicles (e.g., emissions related to electricity generation and mining for battery minerals like lithium, cobalt, nickel, etc.), giving the false impression that these vehicles are, in every case, "clean" and "zero emissions" vehicles.

⁶ Letter from RFA member companies to President Joseph R. Biden. July 27, 2021. <https://ethanolrfa.org/file/2036/RFA-Net-Zero-Commitment-Letter-to-President-Biden-1.pdf>

⁷ EPA (2023). Proposed Rule: Multi-Pollutant Emissions Standards for Model years 2027 and Later Light-Duty and Medium-Duty Vehicles. <https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-multi-pollutant-emissions-standards-model>

At the same time, the proposed EPA regulation ignores the potential of low-carbon renewable liquid fuels like ethanol to reduce GHG emissions in the existing fleet of nearly 280 million liquid-fueled light-duty vehicles. The proposal also ignores the opportunity to drive greater GHG emissions reductions via increased production and use of flex-fuel vehicles (FFVs), which can operate on fuels containing up to 85 percent ethanol (E85). FFVs operating on E85 offer comparable—or better—emissions reductions to today’s electric vehicles (depending on the source of the fuel and the electricity) at a much lower cost. As detailed in the table below, it is important that EPA and the automakers avoid picking winners and losers, and instead support an “all of the above strategy” to emissions reduction.

Vehicle	Vehicle Fuel	Lifecycle Carbon Emissions (grams CO ₂ e/MJ)	Carbon Emissions Reduction vs. Gasoline	Fossil Fuel Content of Vehicle Fuel	Additional Vehicle Purchase Cost vs. Conventional Gasoline Engine Model	Vehicles in U.S. Light Duty Auto Fleet (million)
Flex Fuel Vehicle	E85 (corn kernel fiber ethanol & renewable naphtha)	22	77%	1.6%	\$0-150	23
Flex Fuel Vehicle	E85 (corn starch ethanol & natural gasoline)	53	46%	18%	\$0-150	23
Battery Electric Vehicle	California grid electricity	24	75%	43%	\$10,000-25,000	3
Battery Electric Vehicle	Missouri grid electricity	57	41%	83%	\$10,000-25,000	3

In addition to its environmental benefits, ethanol also makes a vital contribution to our nation’s economy. The 199 ethanol biorefineries across the country serve as crucial drivers of employment and income in the communities in which they operate. Even as Russia’s invasion of Ukraine caused a global energy crisis in 2022, and even as abnormally high inflation rates impacted the U.S. economy, the production of 15.4 billion gallons of ethanol directly employed nearly 79,000 American workers in the manufacturing and agriculture sectors. In addition, the ethanol industry supported 343,000 indirect and induced jobs across all sectors of the economy. Meanwhile, the industry generated \$35 billion in household income and contributed \$57 billion to the national Gross Domestic Product (GDP) in 2022.⁸ These significant employment impacts and economic contributions should be taken into consideration by Congress as it examines potential future energy and climate policies that may impact the biofuels sector.

In conclusion, any clean vehicle policies at the federal level should be carefully crafted and designed in a way that avoids picking technology winners and losers, but instead drives the greatest GHG emissions reductions at the lowest cost. Policies aimed at reducing the emissions impacts of vehicles must recognize that vehicles and fuels work together as a system. When evaluating the

⁸ J.M. Urbanchuk (ABF Economics). “Contribution of the Ethanol Industry to the Economy of the United States in 2022.” Forthcoming (February 2023).

emissions impacts of various transportation options, the impact of the vehicle's fuel must be given at least as much attention as the vehicle itself. Federal vehicle policy should use consistent, fair, and science-based lifecycle GHG analyses for all fuel and vehicle options; set clear and predictable annual GHG reduction requirements; allow low-carbon fuel producers to demonstrate continuous improvement in their individual carbon footprints; include cost-containment measures; and include complimentary measures to remove technical barriers that artificially limit greater use of low-carbon technology.

On behalf of the members of the Renewable Fuels Association, thank you again for the opportunity to share our perspective on the future of ethanol and other low-carbon fuels, and how they can contribute to a future of clean vehicles that are beneficial to the U.S. economy, environment, and public health.

Sincerely,

A handwritten signature in black ink that reads "Geoff Cooper". The signature is written in a cursive, flowing style.

Geoff Cooper
President and CEO

Senator RICKETTS. Thank you.

Senator MARKEY. We thank you, Senator Ricketts.

We will now turn to our esteemed panel of witnesses. We will hear from them in this order. First, we will hear from Kathy Harris. Ms. Harris is the Senior Advocate for Clean Vehicles and Fuels for the NRDC. Before that, she worked as a planner for the State of Delaware addressing policies and programs to mitigate emissions in the transportation sector.

Next, we will hear from Mr. Chris Harto. Mr. Harto is the Senior Policy Analyst on Transportation and Energy for Consumer Reports, where he leads research on electric vehicles, fuel economy, energy efficiency, and other energy issues. He has conducted 20 years of policy research experience for government agencies, national laboratories, universities, and non-governmental organizations (NGO).

Finally, we will hear from Andrew Boyle. Mr. Boyle is Co-President of Boyle Transportation based in the great Commonwealth of Massachusetts and is the first Vice-Chairman for the American Trucking Association. Mr. Boyle is a board member of the American Transportation Research Institute and a past chairman of the Trucking Association of Massachusetts. He grew up in Natick, Massachusetts, the home of Doug Flutie, amongst many other very important citizens of the history of Natick.

We thank you all so much for agreeing to join us today. Ms. Harris from the NRDC, we welcome your testimony first.

STATEMENT OF KATHY HARRIS, SENIOR ADVOCATE, CLEAN VEHICLES AND FUELS, NATURAL RESOURCE DEFENSE COUNCIL

Ms. HARRIS. Chairman Markey, Ranking Member Ricketts, and esteemed members of the subcommittee, thank you for the opportunity today to discuss the benefits of cleaner cars in the United States and the importance of the efforts by this body and other branches of the Federal Government in helping accelerate the transition to a clean transportation system.

My name is Kathy Harris, and I am a Senior Advocate leading the Clean Cars Portfolio at the Natural Resources Defense Council, or NRDC. NRDC is an international nonprofit of scientists, lawyers, and environmental specialists committed to improving public health, tackling the climate crisis, and creating a more affordable, clean energy future.

Zero emission cars and trucks provide the United States with an opportunity to ensure a win for public health and air quality, a win for consumers' pocketbooks and consumer choice, and a win for our economy and our global competitiveness.

The transportation sector is the largest source of greenhouse gas emissions in the United States, but is also a major contributor to nitrogen oxides, particulate matter, and other toxic pollutants. These emissions are not only detrimental to our climate and air quality, but also to human health.

The vehicle tailpipe standards announced by EPA last week will play a key role in improving air quality for communities across the Nation, especially communities that have been historically overburdened by vehicle pollution. EPA projects that their proposed stand-

ards will reduce tailpipe emissions by 56 percent by 2032 from new cars, SUVs, and pickup trucks.

These ambitious and achievable standards work by setting technology-neutral emissions levels for new cars and trucks. Based on automaker commitments and investments, increasing driver demand and the incentives from Congress, EPA projects that manufacturers will choose to reduce emissions from their fleets through increasing the number of zero emission and electric vehicles sold.

Electric and zero emission vehicle technology is a key strategy for reducing pollution from the transportation sector, as they release zero tailpipe emissions, improving air quality and health. Drivers also increasingly want these vehicles for these public health benefits in addition to the lower cost of ownership of the vehicles compared to gas-powered cars.

EPA estimates that strong emissions standards will save the average consumer \$12,000 over the lifetime of the vehicle. The auto industry has already invested billions of dollars in the United States to support a transition to zero emission vehicles. Many manufacturers have announced plans to increase electric vehicles in their offerings, in some cases completely phasing out gasoline vehicles from their lineups over the next decade.

One thing that the Biden Administration and Members of Congress have made clear is that American workers and communities must be able to capture the public health and economic gains associated with transitioning to electric vehicles and building a clean economy. Strong vehicle standards from the Environmental Protection Agency will play a key role in ensuring this occurs.

Strong clean vehicle standards complement the historic Federal investments from Congress. The Inflation Reduction Act will not only help to make new and used electric vehicles more affordable, but it also provides important incentives to increase domestic manufacturing and access to clean vehicles, helping the Country become more competitive globally and bringing more of these public health and work force benefits to our shores.

The Infrastructure Law passed in 2021 will help to build out a robust network of over 500,000 charging stations throughout the Country to help ensure that drivers will have the ability to charge their cars reliably, while tax credits under the Inflation Reduction Act will help catalyze many more charging ports being installed across the Country.

It is clear that clean vehicles are a win for the United States' air and public health, a win for consumers, and a win for the economy. We appreciate Congress and the Federal Government for their leadership in supporting the transition to a clean cars and clean air future.

Thank you for allowing me to speak with you today. I look forward to answering any questions that you may have.

[The prepared statement of Ms. Harris follows:]

**Written Testimony to the
Subcommittee on Clean Air, Climate, and Nuclear Safety,
Senate Committee on Environment and Public Works,
U.S. Senate**

Cleaner Cars: Good for Consumers and Public Health

Kathy Harris
Senior Advocate
Natural Resources Defense Council
April 18, 2023

Chair Markey, Ranking Member Ricketts, and esteemed members of this subcommittee: Thank you for the opportunity today to discuss the benefits of cleaner cars in the United States.

My name is Kathy Harris, and I lead the clean cars portfolio at the Natural Resources Defense Council (NRDC). NRDC is an international nonprofit of scientists, lawyers, and environmental specialists dedicated to protecting natural resources, public health, and the environment. Founded in 1970, NRDC has more than 3 million members and online activists, and we are committed to improving public health, tackling the climate crisis, and creating a more affordable clean energy future.

I have structured my testimony as follows:

- 1) The Importance of Reducing Emissions from The Transportation Sector to Improve Air Quality and Health
- 2) The Environmental and Health Benefits of Transitioning to A Zero-Emission Vehicle Future
- 3) The Economic Benefits of Zero-Emission Vehicles
- 4) The State of the Electric Vehicle Market
- 5) Federal Support for the Growing Electric Vehicle Market

1. The Importance of Reducing Emissions from the Transportation Sector to Improve Air Quality and Health

To address the climate crisis and improve public health, the United States must work to decarbonize the transportation sector, which is now the largest source of greenhouse gas emissions. In the United States, 22 percent of all climate pollution comes from on-road vehicles.¹

¹ Environmental Protection Agency. Notice of Proposed Rule Making: Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles. 40 CFR Parts 85, 86, 600, 1036, 1037, and 1066. April 12, 2023. Hereafter "NRPM". Also see, U.S. EPA. "Fast Facts on Transportation Greenhouse Gas Emissions," <https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions>.

The transportation sector is also a major source of other toxic pollution in the United States. Emissions from cars and trucks on the road include pollutants such as particulate matter (PM), nitrogen oxides (NOx), sulfur oxides, which are detrimental to air quality and human health. According to the Environmental Protection Agency, 54 percent of NOx emissions come from mobile sources with 20 percent of that coming from light-and-medium duty vehicles.² Further, light- and medium- duty vehicles account for approximately 19 percent of PM 2.5 emissions as well. Exposure to these emissions can cause asthma attacks, heart attacks, strokes, cancer, and premature death.

Together, these pollutants not only harm the environment and our air, but also human health. The American Lung Association notes that 4 in 10 Americans live in communities that are impacted by unhealthy levels of air pollution.³ Communities of Color and lower income communities tend to bear the brunt of these emissions and have been historically overburdened with pollution from the transportation sector.

2. The Environmental and Health Benefits of Transitioning to a Zero-Emission Vehicle Future

A key strategy to reducing emissions from mobile sources is to transition to zero-emission vehicles (which can include battery electric vehicles, such as the Nissan Leaf or Chevy Blazer EV, plug-in hybrid electric vehicles, such as the Toyota Prius- or RAV4-Prime, and fuel cell electric vehicles), which, as the name indicates, release zero tailpipe emissions when utilizing the onboard battery. The American Lung Association highlights that shifting to zero-emission vehicles (including passenger and commercial trucks) could reduce transportation NOx emissions by 92% by 2050, fine particulate matter by 61%, and greenhouse gas emissions by 93%.⁴ Reducing these emissions in turn will help to improve health and decrease hospital visits and premature death associated with emissions from gasoline and diesel vehicles.

Electric vehicles (EVs) charge by utilizing power from the electric grid. While emissions from the tailpipe is zero, there are emissions from producing the fuel – in this case electricity. Emissions from producing electricity will vary depending on the mix of resources used (e.g., natural gas, coal, nuclear, wind, solar, etc). However, on today's average U.S. mix which includes coal and natural gas, these vehicles still produce fewer overall emissions than their gasoline counterparts (as show in Figures 1-3).⁵ And overall EV emissions will continue to get cleaner over time as we clean up the electric grid and add more renewable energy sources onto the electric grid.

² NRPM, pages 10- 11. April 12, 2023

³ American Lung Association. (2022). Zeroing In on Healthy Air: State of the Air 2022. <https://www.lung.org/getmedia/13248145-06f0-4e35-b79b-6dfacfd29a71/zeroing-in-on-healthy-air-report-2022.pdf>

⁴ *Ibid.*

⁵ U.S. Department of Energy. Electric Vehicle Emissions Calculator. Alternative Fuels Data Center. Retrieved April 14, 2023, from https://afdc.energy.gov/vehicles/electric_emissions.html

Figure 1: National Averages of annual all electric light-duty vehicles compared to gasoline and other fuel sources.

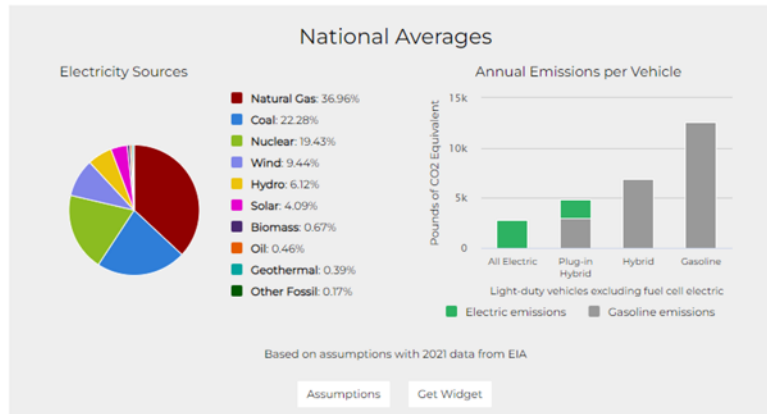


Figure 2: Emissions of annual all electric light-duty vehicles compared to gasoline and other fuel sources.

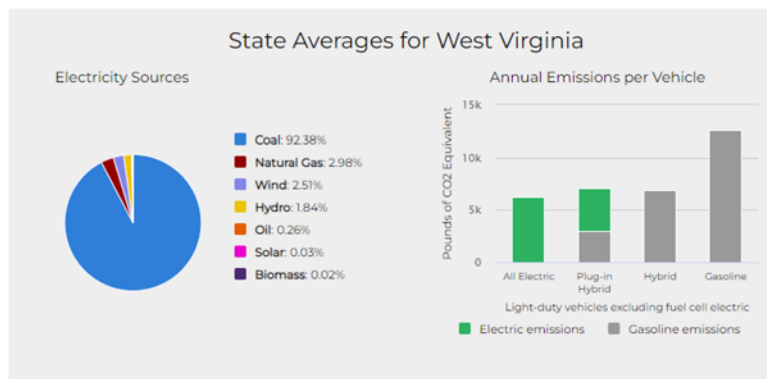
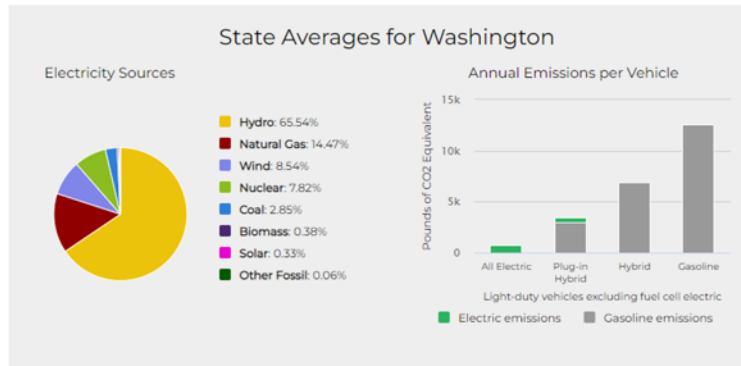


Figure 3: Emissions of annual all electric light-duty vehicles compared to gasoline and other fuel sources.

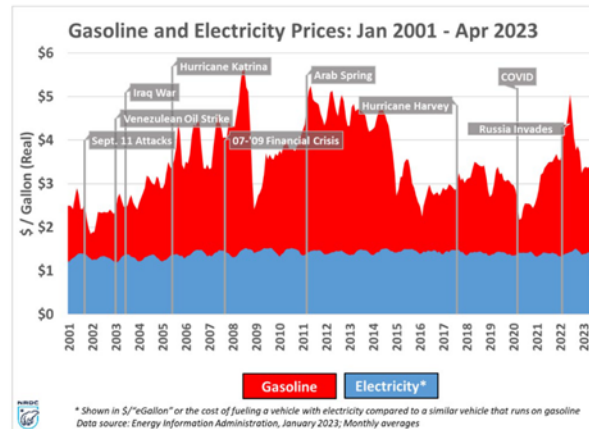


3. The Economic Benefits of Zero-Emission Vehicles

In addition to the environmental, air quality, and health benefits associated with zero-emission vehicles, there are also significant economic benefits for the economy and drivers.

Zero-emission vehicles save drivers money. Electric vehicles have fewer moving parts than gasoline vehicles, and therefore require less maintenance, helping to reduce the overall cost of ownership of the vehicle. Further, the cost of electricity tends to be cheaper than the cost of gasoline, and electricity prices are significantly more stable than the fluctuating costs of gasoline and diesel. This means that drivers will not only save money “refueling” their vehicles but will also be able to better plan and budget for their monthly transportation costs.

Charging at home is roughly the equivalent of fueling up on a dollar-a-gallon gasoline. And the average price of residential electricity, adjusted for inflation, has stayed close to the dollar-a-gallon equivalent mark for over 20 years, as depicted in the chart below, while gas prices go up and down erratically.

Figure 4: The average price of gasoline compared to the price of electricity⁶

The growing availability of medium- and heavy-duty electric vehicles also offer commercial fleets substantial fuel and maintenance cost savings, causing demand to soar for vehicles well suited for electrification today such as delivery vans, short-haul trucks, and transit buses. The United States can expect to see rapid EV adoption rates as fleet familiarity grows and savings accrue.

While the upfront cost of electric vehicles can be higher than a comparable gasoline vehicle in today's prices, an analysis by Atlas Public Policy found that in 2022, electric sedans, SUVs and pickup trucks had a lower total cost of ownership than their gasoline counterparts in large part to annual savings in fuel and maintenance costs.⁷ In addition, rural drivers who on average tend to drive further and have larger vehicles stand to benefit the most from electrifying their vehicles. An analysis by the MJ Bradley and Associates on clean transportation strategies for rural communities showed the lifetime savings for an EV ranged from \$27,000 to \$44,000 in the rural areas compared to \$22,000 to \$31,000 in urban areas.⁸

The upfront costs of EVs are also decreasing. The U.S. Department of Energy estimates that electric vehicle battery costs in 2022—which is the most expensive part of an electric vehicle—

⁶ Baumhefner, M. (2017, August 16). Fight Fascists, Save Money: Go Electric. Natural Resources Defense Council. from <https://www.nrdc.org/bio/max-baumhefner/fight-fascists-save-money-go-electric>

⁷ Atlas Public Policy. (2022). Total Cost of Ownership Analysis. <https://atlaspolicy.com/wp-content/uploads/2022/01/Total-Cost-of-Ownership-Analysis.pdf>

⁸ Lowell, D., Van Atten, C., Culkin, J., & Langlois, T. (2020, November). Clean transportation strategies for rural communities in the Northeast and MidAtlantic States. Union of Concerned Scientists. https://www.ucsusa.org/sites/default/files/2020-11/rural-transportation-opportunities_0.pdf; also see Moura, C. (November, 2021). 5 Ways Rural Drivers Benefit from Electric Vehicles [Blog post]. Union of Concerned Scientists. <https://blog.ucsusa.org/cecilia-moura/5-ways-rural-drivers-benefit-from-electric-vehicles/>

were nearly 90% cheaper than in 2008, with battery costs now reaching about \$153/kwh.⁹ And the International Council on Clean Transportation (ICCT) estimates that electric vehicles will reach price parity with gasoline vehicles across multiple classes between 2024-2032.¹⁰

Additionally, tax credits from the Inflation Reduction Act, as well as state and manufacturer rebates also can help to lower the upfront cost of electric vehicles. A recent report by Energy Innovation and ICCT shows that IRA will increase access to EVs and allow them to be at cost parity several years earlier, allowing for a jump in market share from 34% by 2030 to as high as 61% by 2030.¹¹

Further, there are additional economic benefits from reduced pollution and health costs as a result of the transition to zero-emission vehicles. The American Lung Association estimates that transitioning the transportation sector to zero-emission vehicles and non-combustion electricity generation could generate over \$1.2 trillion in public health benefits through 2050, as well as \$1.7 trillion in climate benefits from avoided costs of having to address and adapt to severe climate change.¹²

4. The State of the Market

A global transition to ZEVs is underway, and now the United States must determine if we will lead this transition or miss out on the benefits the transition can bring to our shores. This is not dissimilar to the technology transitions from landlines and payphones to mobile smartphones; from VHS tapes to on-demand services; or modern-day computers that are a billion times faster than the computer we put on Apollo 11 to send Neil Armstrong to the moon.¹³ Most automakers now see the transition to ZEVs as inevitable and necessary, and many have committed to transitioning their full ZEV fleet within the next decade.¹⁴

Sales of electric vehicles in the United States continue to increase annually. According to the Alliance for Automotive Innovation, electric vehicles accounted for 7 percent of the new vehicles sold in the United States 2022—an increase from 4.4 percent in 2021. In December

⁹ U.S. Department of Energy. (2023, January 9). FOTW #1272, January 9, 2023: Electric vehicle battery pack costs in 2022 are nearly half the cost in 2015. Energy.gov. <https://www.energy.gov/eere/vehicles/articles/fotw-1272-january-9-2023-electric-vehicle-battery-pack-costs-2022-are-nearly-half-the-cost-in-2015>

¹⁰ Slowik, P., Isenstadt, A., Pierce, L., & Searle, S. (2022, October). Assessment of light-duty electric vehicle costs and consumer benefits in the United States in the 2022–2035-time frame. International Council on Clean Transportation. <https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf>

¹¹ Energy Innovation. (2023, January). Analyzing the Impact of the Inflation Reduction Act on EV Uptake in the U.S. [Report]. <https://energyinnovation.org/wp-content/uploads/2023/01/Analyzing-the-Impact-of-the-Inflation-Reduction-Act-on-EV-Uptake-in-the-U.S..pdf>

¹² American Lung Association. (2022). Zeroing In on Healthy Air: State of the Air 2022.

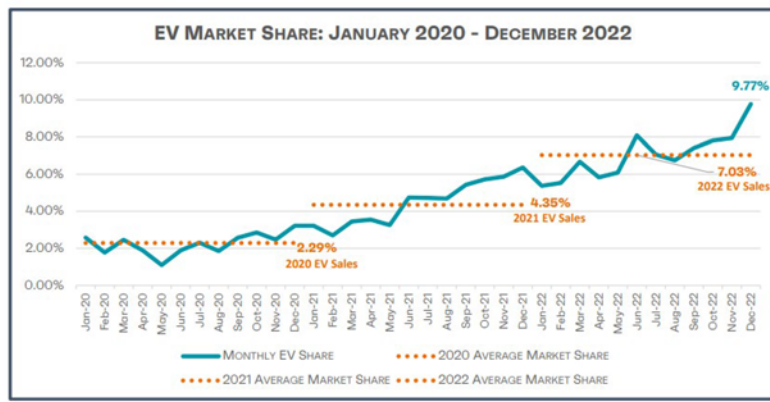
<https://www.lung.org/getmedia/13248145-06f0-4e35-b79b-6dfacfd29a71/zeroing-in-on-healthy-air-report-2022.pdf>

¹³ Adobe. (2022, November 8). Fast forward: Comparing 1980s supercomputer to modern smartphone. Adobe Blog. <https://blog.adobe.com/en/publish/2022/11/08/fast-forward-comparing-1980s-supercomputer-to-modern-smartphone>

¹⁴ ERM, EDF (September 2022), *Electric Vehicle Market Update*. https://blogs.edf.org/climate411/files/2022/09/ERM-EDF-Electric-Vehicle-Market-Report_September2022.pdf. Also see <https://www.nytimes.com/2023/04/11/business/energy-environment/cars-electric-vehicles-epa.html>.

2022, EVs were almost 10% of new vehicle sales across the U.S. And EV sales were up 44 percent in 2022 even though there was an overall decrease in overall total light-duty vehicle sales of 11 percent.¹⁵ The U.S. market is beginning to catch up with the two other largest markets in the world: Europe, where electric vehicle sales soared to 23% in 2022, with sales surging to a record 38% by December 2022; and China with electric vehicle sales hitting a 30% share by in 2022.¹⁶

Figure 5: EV Market Share: January 2020- December 2022



In addition, growing demand from customers for these vehicles, automakers are also supporting the transition to zero-emission vehicles. Globally, automakers and battery manufacturers have announced over \$860 billion of investments to accelerate the transition to zero-emission vehicles, with more nearly a quarter (\$210 billion) of these investments going to projects in the United States more than any other country in the world.¹⁷ Investments in the U.S. are being spurred with the enactment of the Inflation Reduction Act (IRA) and the Infrastructure Investments and Jobs Act (IIJA), together with state and federal vehicle standards. These investments are helping to onshore the electric vehicle industry—creating jobs in the U.S. and helping to make the country a competitive leader in the electric vehicle industry.

¹⁵ Alliance for Automotive Innovation. (2023). 2022 Q4 Electric Vehicle Report [PDF].

<https://www.autosinnovate.org/posts/papers-reports/Get%20Connected%202022%20Q4%20Electric%20Vehicle%20Report.pdf>

¹⁶ CleanTechnica (February 2, 2023), "Open the Gates! 25% BEV Share in Europe and InsideEVs (February 8, 2023), "China: Nearly 6 Million Plug-in Cars Were Sold in 2022."

¹⁷ Atlas Public Policy, NRDC (January 2023), https://www.atlasevhub.com/data_story/210-billion-of-announced-investments-in-electric-vehicle-manufacturing-headed-for-the-u-s/#_ftn4. Also see the Alliance for Automotive Innovation (March 2023). The Future Is Electric: Lets Drive Together <https://www.autosinnovate.org/posts/communications/The%20Future%20Is%20Electric%20Infographic>

There are also an increasing the number of makes and models of zero-emission vehicles available to drivers. At the end of 2022, there were 91 electric vehicle models available for sale, including cars, utility vehicles, pickup trucks, and vans.¹⁸ And many automakers have already announced plans to phase out gasoline vehicles from their offerings and increase the number of electric models available in their fleets. Announced plans include:

- General Motors—100% electric vehicle sales in U.S. by 2035 and carbon neutral by 2040¹⁹
- Volvo—will only make electric vehicles by 2030²⁰
- Volkswagen—half of its vehicle sales in the U.S. will be electric by 2030; fully electric a few years later²¹
- Honda—announced a fully electric vehicle lineup by 2040. Estimates that 40% of North American sales will be electric by 2030²²
- Toyota—will introduce 30 new all-electric vehicles by 2030.²³

The United States is also seeing an increase in electric vehicle charging stations. While it is estimated that 80% of electric passenger vehicle charging happens at home,²⁴ a robust charging network helps ensure drivers can charge while enroute, while also providing opportunities for drivers to charge their vehicles who may not have the ability to do so at home or at work. Currently, there are over 155,000 EV charging ports at over 61,000 locations throughout the United States.²⁵

5. Federal Support for the Growing Zero-Emission Vehicle Market

The Inflation Reduction Act and the Infrastructure Investment and Jobs Act will also help to support the growing electric vehicle market. The Inflation Reduction Act is not only providing incentives to drivers to purchase electric vehicles—helping to offset the upfront costs of the vehicles—but also providing robust incentives to vehicle manufacturers to onshore the electric vehicle supply chain here in the United States.

The Infrastructure Investment and Jobs Act has dedicated \$7.5 billion to further expand and buildout a robust network of charging infrastructure throughout the country. These investments

¹⁸ Alliance for Automotive Innovation (March 2023). The Future Is Electric: Lets Drive Together <https://www.autosinnovate.org/posts/communications/The%20Future%20Is%20Electric%20Infographic>

¹⁹ General Motors, “General Motors, the Largest U.S. Automaker, Plans to be Carbon Neutral by 2040,” Press Release, January 28, 2021.

²⁰ Volvo Car Group, “Volvo Cars to be fully electric by 2030,” Press Release, March 2, 2021.

²¹ Volkswagen Newsroom, “Strategy update at Volkswagen: The transformation to electromobility was only the beginning,” March 5, 2021. <https://www.volkswagen-newsroom.com/en/stories/strategy-update-at-volkswagen-the-transformation-to-electromobility-was-only-the-beginning-6875>

²² Honda News Room, “Summary of Honda Global CEO Inaugural Press Conference,” April 23, 2021. Accessed June 15, 2021 at <https://global.honda.newsroom/news/2021/c210423eng.html>.

²³ Toyota Motor Corporation, “Video: Media Briefing on Battery EV Strategies,” Press Release, December 14, 2021. Accessed on December 14, 2021 at <https://global.toyota/en/newsroom/corporate/36428993.html>.

²⁴ ChargeHub. A Beginner’s Guide to Electric Cars: How to Charge an EV at Home. <https://chargehub.com/en/home-charging-guide-electric-vehicles.html>

²⁵ U.S. Department of Energy. Alternative Fuels Data Center Station Locator. <https://afdc.energy.gov/stations/#/analyze?fuel=ELEC> (Accessed April 13, 2023)

will not only increase the amount of charging stations on the United States highways—connecting people across the country—but also build out charging infrastructure in communities.

Most recently, the Environmental Protection Agency proposed multi-pollutant emission standards for Model Years 2027 and Later Light-Duty and Medium-Duty vehicles. Based on the market trends, automaker commitments, and investments coming from the Inflation Reduction Act and the Infrastructure Investment and Jobs Act, EPA estimates that in order to achieve the proposed Model Year 2032 tailpipe greenhouse gas emissions, car companies will find it most cost effective to meet these standards by increasing sales of electric vehicles. For the reasons discussed in this testimony, it is vital that EPA adopt the most stringent standards possible to help accelerate the transition to clean cars and trucks to guarantee the myriad of benefits they bring to the United States and its residents.

6. Conclusion

There are major pollution and emissions problems to address in the United States, and clean cars are a key piece of the solution. States, Congress, key industry players, and consumers are spearheading the transition to zero emissions, but it's up to EPA to finish the job and set the strong standards needed to fully realize a future in which the cleanest vehicles can proliferate. Thank you for the opportunity to testify today on this important and timely matter.

Senate Committee on Environment and Public Works
 Subcommittee on Clean Air, Climate, and Nuclear Safety
 Hearing Entitled, “*Cleaner Vehicles: Good for Consumers and Public Health*”
 April 18, 2023
 Questions for the Record for Kathy Harris
 Responses

Ex-Officio Chairman Carper:

1. Many communities of color and low-income families live in areas with very high levels of air pollution from cars and trucks. These communities experience disproportionate pollution exposures, and disproportionate harms to their health.
 - a. How will the Environmental Protection Agency’s (EPA) proposed greenhouse gas emissions standards reduce these disproportionate air pollution harms?

While NRDC can’t speak on behalf of these communities directly, we are happy to share thoughts on this informed by the EPA’s Science Advisory Board’s report on this topic for the agency’s last truck regulation and informed by our partnership with organizations like the Moving Forward Network, that continue to lead the charge and educate EPA and others on the unjust and deadly impacts caused by air pollution and the best solutions for addressing this.

Irrespective of socioeconomic status, communities of color are exposed to higher levels of outdoor air pollution and traffic-related sources (e.g., heavy-duty diesel vehicles) are among the top four source sectors contributing to these disparities. In the United States, 22 percent of all climate pollution comes from on-road vehicles,¹ and the transportation sector is a major source of other toxic pollution, such as particulate matter (PM) and nitrogen oxides (NOx), which are detrimental to air quality and human health. Despite the achievements of prior standards in securing overall reductions in emissions by all source types, the existence of transportation sector pollution at the regional, city-level, and neighborhood level, continues to allow disparities to persist in vulnerable communities, according to EPA’s Science Advisory Board.²

EPA’s proposed light-and-medium duty vehicle (LMDV) regulations include both greenhouse gas emission standards as well as criteria pollutant standards—helping to clean up the air quality on our nation’s roads and improving public health. According to the Environmental Protection Agency, 54 percent of NOx emissions come from mobile sources with 20 percent of that coming from light-and-medium duty vehicles.³ Further, light- and medium- duty vehicles account for approximately 19 percent of PM 2.5 emissions as well. Under EPA’s proposed LMDV

¹ Environmental Protection Agency. Notice of Proposed Rule Making: Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles. 40 CFR Parts 85, 86, 600, 1036, 1037, and 1066. April 12, 2023. Hereafter “NRPM”. Also see, U.S. EPA, “Fast Facts on Transportation Greenhouse Gas Emissions,” <https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions>.

² DRAFT Science Advisory Board Regulatory Review Report of Science Supporting EPA Decisions for the Proposed Rule: Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards (RIN 2060-AU41) (2022)

³ NRPM, pages 10-11. April 12, 2023

regulations, greenhouse gas emissions will be reduced by 56% compared to a model year 2026 vehicle in model year 2032. Particulate matter emissions will be reduced by 95%, while emissions from NOx and NMOG will be reduced by 66-76%, depending on the vehicle size.

EPA's proposed heavy-duty vehicle regulations are only for greenhouse gas emissions. Despite making up only 3.5 percent of the on-road fleet, class 4 to 8 medium- and heavy-duty vehicles emit an estimated 469 million metric tons of greenhouse gas emissions annually — approximately 22 percent of all greenhouse gas emissions from the on-road vehicle fleet. Medium- and heavy-duty vehicles are also responsible for 52 percent of the NOx and 56 percent of the PM emitted by on-road vehicles, contributing to poor air quality and negative health impacts in communities across the nation.

The proposed standards build upon the agency's previous round of greenhouse gas emissions standards established, in 2016, and comes following the finalization of the agency's NOx and PM emission standards last year. EPA estimates that its proposed standards for heavy-duty vehicles would avoid 1.8 billion metric tons of greenhouse gas emissions from 2027 through 2055. However, there are a number of significant strengthening measures and coordination with frontline and fenceline communities that need to occur to ensure that a finalized rule results in much needed benefits for environmental justice communities.

Communities along freight corridors and highways bear the brunt of the health and environmental impacts caused by the freight transportation sector's harmful emissions. It is important that EPA and other stakeholders heed their calls for action and that EPA be responsive to the evidence base that frontline and fenceline communities continue to provide in their calls for agency standards that are stringent enough to ensure that the best transportation emissions reducing technologies are deployed in their communities — such as zero emission and battery electric vehicles, which do not emit criteria pollutants like PM and NOx. EPA's standards will be most impactful if they are as stringent as is feasible and put the nation's transportation sector on a path to 100% of new vehicles being zero-emissions by 2035.

b. How will the clean vehicle investments included in the Inflation Reduction Act and the Bipartisan Infrastructure Law help to advance equitable access to clean, zero-emission vehicles in communities historically overburdened with transportation pollution?

The clean vehicle investments in the Inflation Reduction Act (IRA) can be divided into three main categories: tax credits, grants and loans for clean vehicle manufacturers, and grants for heavy-duty fleet electrification. Specific IRA investments to advance equitable access to clean, zero-emission vehicles include several tax credits to help purchasers of new or used personal vehicles and commercial vehicles defray the upfront costs of clean vehicle purchases, as well as investments to help individuals and businesses install charging infrastructure.

According to the White House, these investments are also geared towards bringing the clean vehicles supply chains home and offer the opportunity to increase employment in ways that ensure the economic benefits of EVs are equitably distributed, across both urban and rural populations, as well as among communities of color, Tribal communities, and disadvantaged and

underserved communities.⁴ In fact, the Blue Green Alliance has found that the transportation provisions of the law are expected to create and support over 520,000 jobs over ten years.⁵

Additionally, the more than \$24.5 billion in clean vehicles investments included in the Bipartisan Infrastructure Law complement the IRA's investments, as well as dozens of other federal initiatives designed to drive domestic manufacturing, bring clean vehicles supply chains home, and to build a national network of electric vehicle charging infrastructure.⁶

Combined, the investments from these laws will accelerate the growth of the EV market and increase the number of zero-emission vehicles on roads by lowering the cost of these vehicles and their fueling infrastructure. These clean vehicle investments will also improve air quality and health in the communities near highways, while also helping drivers in these communities' access and utilize these vehicles.

Most notably, the infrastructure law includes \$2.5 billion in competitive grant funding (of which half is prioritized for rural and low- and moderate-income communities), and IRA's Clean Vehicles Tax Credit (Section 30D) and Previously Owned Clean Vehicles Credit (Section 25E) are targeted towards low- and middle-income households. These credits can also be transferred to the dealership, enabling new and used car buyers to receive the credit as a rebate at the point of sale. This incentive program is vital to improving access to zero-emission vehicles for low-moderate income (LMI) communities, many of which are historically overburdened with transportation pollution. This is because most drivers in the United States purchase used vehicles⁷—and this percentage is even higher for LMI community members. Providing a pathway for the tax credit to be transferred to the dealership allows for drivers who may not have a high enough tax burden to obtain the full incentive. Further, drivers will be able to receive the incentive immediately without having to wait for reimbursement from the federal government after tax season – which a number of drivers cannot afford to do.

Additionally, the IRA's incentives for medium- and heavy-duty ZEVs (which are highlighted in our response to question 2) can help ensure that more zero-emission trucks and buses will be operating in communities that disproportionately suffer from toxic air pollution.

⁴ U.S. DOT Rural EV Toolkit: <https://www.transportation.gov/rural/ev/toolkit/ev-benefits-and-challenges/community-benefits>

⁵ Blue Green Alliance IRA Fact Sheet: <https://www.bluegreenalliance.org/wp-content/uploads/2022/08/BGA-Clean-Vehicle-IRA-Factsheet-82322-FINAL.pdf>

⁶ White House Fact Sheet: <https://www.whitehouse.gov/briefing-room/statements-releases/2023/02/15/fact-sheet-biden-harris-administration-announces-new-standards-and-major-progress-for-a-made-in-america-national-network-of-electric-vehicle-chargers/#:~:text=The%20path%20to%20net%2Dzero,%2C%20critical%20minerals%2C%20and%20materials>

⁷ See: Bureau of Transportation Statistics, *New and Used Passenger Car and Light Truck Sales and Leases*, <https://www.bts.gov/content/new-and-used-passenger-car-sales-and-leases-thousands-vehicles>; and MotorTrader.com, *Consumers Three Times More Likely to Buy Used Cars Over New*, October 2019, <https://www.motortrader.com/motor-trader-news/automotive-news/majority-buy-consumers-opt-used-new-cars-28-10-2019>

2. Major trucking fleets, heavy-duty vehicle and engine manufacturers, and U.S. states have announced plans to increase the use of heavy-duty zero-emissions technologies in the coming years. The Bipartisan Infrastructure Law and the Inflation Reduction Act together include many incentives for the development, production, and sale of electric vehicles, electric vehicle charging infrastructure, and hydrogen, which are expected to spur significant innovation in the heavy-duty sector.

a. How have the investments made last Congress in heavy-duty zero-emitting vehicles significantly lowered the compliance costs for manufacturers who will need to meet these new rules?

Both the Bipartisan Infrastructure Law and the Inflation Reduction Act (IRA) include incentives to support the development of and market for ZEV technologies and their infrastructure. These investments are facilitating the decarbonization of the nation's most polluting sector. Some highlights include:

- \$7.5 billion in formula and discretionary funding for the build-out of public EV charging infrastructure.
- \$5 billion as part of the Clean School Bus program.
- \$1 billion in grants for Class 6 and 7 zero-emission vehicles (\$400 million of which will be going to communities in EPA NAAQS nonattainment areas).
- Tax credit programs that will help bring down the cost of assets, including the Section 45W Commercial Clean Vehicle tax credit to aids fleets purchasing commercial zero-emission vehicles and the Section 30C Alternative Fueling Property tax credit for charging/refueling infrastructure.
- Manufacturing investment programs for facilities building advanced technology vehicles, like electric vehicles.
- Funds for transit buses through expansion of the Low and No-Emission grant program.
- Programs such as the Congestion Mitigation and Air Quality Improvement, Greenhouse Gas Reduction Fund, and the Diesel Emissions Reduction fund whose funds can be leveraged for the purchase of zero-emission vehicles and supporting equipment.

Studies demonstrate that these investments have a significant impact on lowering the up-front cost of zero-emission vehicles, supporting the economic feasibility of purchasing zero-emission trucks and buses. For example, a study by Roush Industries found that because of IRA grants and incentives, electric freight trucks and buses will be less expensive than their combustion engine counterparts as early 2023 - i.e., right now.⁸ Another report, produced by the consulting group ERM, found that IRA grants alone could increase the number of zero-emission vehicle sales by

⁸ Environmental Defense Fund (2022): http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6_20220209.pdf?_gl=1*j4z0wh*_ga*MTA4MTc0Mzc5Ni4xNjgzNjc2OTYx*_ga_2B3856Y9QW*MTY4MzY3Njk2MC4xLjEuMTY4MzY3ODMwMy42MC4wLjA.*_ga_Q5CTTQBJD8*MTY4MzY3Njk2MS4xLjEuMTY4MzY3ODMwMy42MC4wLjA.

over 74,000 vehicles between 2023 and 2031.⁹ Congress' investments in zero-emission technologies and their supporting infrastructure will ensure that manufacturers will face lower compliance costs to meet these new rules.

b. Is it true that EPA provides flexibility for different types of heavy-duty vehicles to comply with the new rules? If yes, please expand upon this.

Yes, EPA's new rules provide flexibility for different types of vehicles to meet the new standards. For example, the proposed rule allows manufacturers to choose what set of emission control technologies are best suited for their vehicle fleets. Additionally, the proposed standard does not mandate the use of a specific technology, and the agency's analysis projects that internal combustion engine and zero-emission vehicle technologies will both play a role in reducing greenhouse gas emissions. Finally, EPA's proposed rule includes emission standards that vary by vehicle type/use and utilizes a trading program that allows manufacturers to bank credits for future years, and average and trade credits to meet the new standards. These provisions provide several pathways that will help manufacturers comply with the new rules.

3. During the hearing, several members of the Committee discussed with you issues surrounding critical mineral procurement for battery electric vehicles.

a. Please talk further about how electric vehicle manufacturers are reducing their reliance on critical minerals and building a more sustainable battery.

There are several ways that electric vehicle manufacturers are reducing their reliance on critical minerals:

Battery recycling

Recycling old batteries provides a source of materials for new batteries without new mining, reduces the lifecycle emissions associated with battery production, and helps the industry move towards a circular economy that requires a decreasing amount of new material inputs.

An EV battery is essentially a small mineral reserve filled with extremely concentrated and high-quality materials. Advanced recycling procedures that allow critical minerals and other materials to be recovered from these batteries at the end of their lives and incorporated into new batteries will reduce waste, as well as the need for raw material mining and refining. In fact, researchers at University of California, Davis concluded that battery recycling in the U.S. could supply up to 60% of cobalt, 53% of lithium, 57% of manganese, and 53% of nickel globally in 2040.¹⁰

⁹ Environmental Defense Fund, *Electric Vehicle Market Update*, September 2022, https://blogs.edf.org/climate411/files/2022/09/ERM-EDF-Electric-Vehicle-Market-Report_September2022.pdf?_gl=1*19qaps*_ga*MTA4MTc0Mzc5Ni4xNjgzNjc2OTYs*_ga_2B3856Y9QW*MTY4MzY3Njk2MC4xLjEuMTY4MzY3OTgwMC4zOS4wLjA.*_ga_Q5CTTQBJD8*MTY4MzY3Njk2MS4xLjEuMTY4MzY3OTgwMC4zOS4wLjA.

¹⁰ Jessica Dunn, Margaret Slattery, Alissa Kendall, Hanjiro Ambrose, and Shuhan Shen, *Circularity of Lithium-Ion Battery Materials in Electric Vehicles*, Environmental Science & Technology 2021 <https://pubs.acs.org/doi/abs/10.1021/acs.est.0c07030>

Additionally, minerals for EVs can be used again and again, whereas fossil fuel vehicles require a constant input of extracted oil – which can only be used once, and which has a history of environmental and human rights issues. EPA highlights this in the Proposed Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles by stating “utilization of critical minerals is different from the utilization of foreign oil, in that oil is consumed as a fuel while minerals become a constituent of manufactured vehicles. Minerals that are imported for vehicle production remain in the vehicle and can be reclaimed through recycling”¹¹ Moreover, using recycled materials in new batteries can also reduce the lifecycle emissions associated with battery production by 7-17% due to energy saved by avoiding upstream raw material mining and processing.¹²

One example of battery recycling occurring domestically is Redwood Materials, which partners with auto manufacturers like Volkswagen, Audi, Tesla, Ford, and Volvo¹³ to ensure 95% of materials are recovered on average from old batteries at their electric vehicle battery recycling facility in Nevada and reused in new battery components.

New battery technologies

Improving battery energy density (which is measured in watt-hours per kilogram) increases the amount of energy that can be stored using the same amount of materials. Increasing energy density is important not only for reducing demand for battery minerals but also for improving the range of electric vehicles in how far they can travel on a singular charge.¹⁴

There are many opportunities for manufacturers to be able to store more energy per kilogram of battery materials, including improvements in current lithium-ion chemistries or developing entirely new chemistries. Different chemistries can also reduce or even eliminate reliance on the five critical minerals commonly used in today’s EV batteries, as supported by analysis from BloombergNEF’s EV outlook.¹⁵

Already since 2010, improvements in lithium-ion chemistries have tripled the energy density of lithium-ion batteries which has contributed to an 89% drop in the price of a battery pack over the same period (on a per energy capacity, or kWh, basis).¹⁶ Further, emerging lithium-ion improvements – like material substitutions – could again double energy density by 2025¹⁷ and allow lithium-ion batteries to deliver improved performance with a smaller battery.

¹¹ NPRM at 383

¹² ICCT, *Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions*. February 2018. https://theicct.org/sites/default/files/publications/EV-life-cycle-GHG_ICCT-Briefing_09022018_vF.pdf pg 8

¹³ Korosec, Ford, Volvo join Redwood Materials to launch free EV battery recycling program in California. February 2022. <https://techcrunch.com/2022/02/17/ford-volvo-join-redwood-materials-to-launch-free-ev-battery-recycling-program-in-california/>

¹⁴ Dragonfly Energy, *Why Does Energy Density Matter In Batteries*. December, 2022. <https://dragonflyenergy.com/why-does-energy-density-matter-in-batteries/>

¹⁵ McKerracher, et al., *Electric Vehicle Outlook 2022*, 139-141.

¹⁶ CleanTechnica, BloombergNEF: Lithium-Ion Battery Cell Densities Have Almost Tripled Since 2010. February 2020. <https://cleantechnica.com/2020/02/19/bloombergnef-lithium-ion-battery-cell-densities-have-almost-tripled-since-2010/>

¹⁷ Bloch, Newcomb, Tyson, *Breakthrough Batteries: Powering the Era of Clean Electrification*. 2019. <https://rmi.org/insight/breakthrough-batteries/>

Additionally, investing in and improving lithium-ion batteries with different chemical makeups can reduce the need for specific metals that are especially constrained by supply chain concentration issues linked to human rights concerns (e.g. cobalt from small-scale mines in the Democratic Republic of the Congo) or geopolitical conflict (e.g. nickel from Russian mines).¹⁸ For example, lithium-iron phosphate (LFP) batteries use iron instead of cobalt or nickel, which is a much more abundant material,¹⁹ and companies like Tesla are using LFP batteries in their standard-range EVs today.

Researchers are currently developing novel battery chemistries entirely different than lithium-ion batteries that could be used in EVs. Potential new chemistries and materials include eliminating cobalt from the cathode and graphite from anode through technologies like zinc-air and silicon anodes and reducing price, energy, toxicity, flammability, and metal inputs through technologies like lithium-metal batteries. Sodium-ion battery research also show that they could be a sustainable alternative for short-range EV batteries with carbon anodes and cobalt-free cathodes.²⁰ Companies like Ionic Materials are developing solid polymer (non-aqueous) electrolytes – the material that ions flow through to pass between the anode and the cathode during charging and discharging – which improve safety and chemical stability of batteries thus allowing for more volatile chemistries such as lithium-metal anodes used in solid-state batteries.²¹ Solid-state batteries are also much smaller, and therefore can have higher maximum energy densities than lithium-ion batteries.

Through strategies like these, batteries can deliver the same amount of energy storage with less mineral extraction which will reduce costs as well as environmental and frontline community impacts.

b. Is there anything you want to expand upon in terms of critical minerals that was not discussed during the hearing?

Electrifying fleets presents an opportunity to boost U.S. manufacturing. According to an Li-Bridge analysis (a group convened by DOE), U.S. can capture 60% of the economic value from U.S. domestic battery demand in 2030 – double the 30% that would be captured under a business-as-usual case. \$2.8 billion in total has been awarded through IIJA which already closes the gap by 5-10%. Well-implemented IRA incentives that provide public funding while spurring private investment combined with additional government action should be able to close the remainder of the gap to yield an additional \$33 billion value and 100,00 direct domestic jobs.²²

Automakers are already working to integrate their supply chains and build out domestic infrastructure. Investment announcements from U.S. electric vehicle and battery manufacturers (\$210 billion) represent nearly a quarter of all global investment announcements – more than any

¹⁸ <https://www.law.berkeley.edu/wp-content/uploads/2020/07/Sustainable-Drive-Sustainable-Supply-July-2020.pdf> pg 4

¹⁹ <https://www.nrel.gov/docs/fy13osti/55947.pdf>

²⁰ <https://pubs.acs.org/doi/pdf/10.1021/acscenergylett.0c02181> pg 3546

²¹ <https://ionicmaterials.com/batteries/>

²² https://naatbatt.org/wp-content/uploads/2023/02/Final-ACCESS_Li-Bridge-Industry-Report_pages_R6-for-print-1.pdf

other country.²³ EPA's strong standards align with automakers goals to electrify and grow domestic supply chains. Already, 57% of battery cells and 84% of battery packs that were used in vehicles sold in the U.S. from 2010 to 2021 were manufactured in the U.S.²⁴

As battery manufacturing continues to grow in the U.S., so will the demand for minerals needed to build electric vehicle batteries. To successfully transition away from fossil fuels, we need to mine minerals for EVs, but we need to do it right. Mining on federal lands on the U.S. continues to be guided by the 1872 Mining Law, which governs how hardrock minerals like gold, silver, platinum, and copper are extracted on 350 million acres of federal lands. Under this 150-year-old law, mining continues to be interpreted as the "highest and best use" of the land, meaning that recreation, hunting, grazing, renewable energy development, and all other uses are deemed secondary to mining. This has led to more than a century of environmental degradation and contamination.

Growing demand for minerals to power our electrified future are creating pressure for domestic mining to expand at a time when our mining law remains stuck in the distant past. The *Clean Energy Minerals Reform Act* offers solutions to these problems that will bring mining in the U.S. into the 21st Century, help provide certainty to communities and industry, and ensure that U.S. taxpayers-owned resources are not freely taken by industry. The bill will be introduced by Representative Grijalva in mid-May. Senator Heinrich will also be introducing a similar bill in the Senate at the same time.

The U.S. is on the right path to build a robust, secure, and clean domestic vehicle supply chain, but we must continue invest in manufacturing, modernize the mining sector, and use minerals as efficiently as possible in order to meet our goals and maximize economic benefits.

EVs will always be a more environmentally friendly choice than fossil-fuel powered cars simply because they do not rely on continuous fossil fuel extraction which has destroyed aquifers, polluted the air and harmed the health of so, so many over the past century.²⁵ Once this oil is burned, it is gone forever. Conversely, an old EV battery is filled with extremely concentrated and high-quality materials that can be reused again and again.²⁶ Transitioning to EVs creates an opportunity to reduce long-term reliance on extractive industries that will never be an option for fossil fuel vehicles.

The most effective strategy to meet demand for EV battery minerals and limit the harms from battery supply chains is reducing the type and amount minerals needed. While there are many actions that will reduce harmful impacts of extracting minerals, these harms cannot be fully

²³ https://www.atlasevhub.com/data_story/210-billion-of-announced-investments-in-electric-vehicle-manufacturing-headed-for-the-u-s/

²⁴ <https://www.energy.gov/eere/vehicles/articles/fofw-1278-february-20-2023-most-battery-cells-and-battery-packs-plug>

²⁵ Melissa Denchak, "Fossil Fuels: The Dirty Facts," NRDC, June 1, 2022, <https://www.nrdc.org/stories/fossil-fuels-dirty-facts>.

²⁶ Transportation & Environment, "Recycling Drastically Reduces Dependence on Imported Electric Vehicle Battery Materials," March 30, 2021, <https://www.transportenvironment.org/discover/recycling-drastically-reduces-dependence-imported-electric-vehicle-battery-materials/>.

mitigated because extraction inherently requires some level of energy, land, and chemical use.²⁷ Therefore, reducing the amount of mining needed is key to reducing harms. Given the rapid increase in EV production and sales, increasing material efficiency through improvements in battery technology, second-life applications for vehicle batteries, and better recycling will pay dividends over the coming years and decades. These are long-term policies that will not eliminate the need for mining of battery materials over the next few years. However, they will reduce the amount of new mining we will need in the future and put us on the road to a truly clean and just economy.

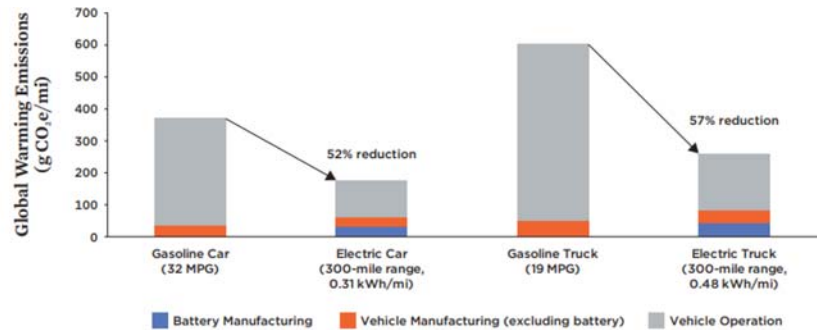
4. **During the hearing, I submitted for the record a study from the International Energy Agency which compares the lifecycle greenhouse gas emissions of a mid-size battery electric vehicle with an internal combustion engine vehicle. The study found that, considering the mining of critical minerals, electric vehicles produce substantially less in greenhouse gas emissions, per vehicle lifetime, compared to internal combustion vehicles.**

a. Do you know of any additional studies that show similar comparisons?

Yes. The Union of Concerned Scientists found that electric cars and pickup trucks produced fewer global warming emissions than gasoline vehicles when considering fueling, that is electricity versus gasoline.²⁸ The study acknowledges that the manufacturing of an electric vehicle (EV) may initially produce more greenhouse gas emissions (due to the current battery supply chain), but over the lifespan of the vehicle, emissions are between 52-57% less than a comparable gasoline car and truck. The authors state that "...[M]ost of the global warming emissions over the lifespan of a vehicle occur during its use, so the reductions from driving an EV more than offset the higher manufacturing emissions."

²⁷ Madeline Stone, "Mining Is a Polluting Business. Can New Tech Make It Cleaner?" *National Geographic*, May 13, 2022, <https://www.nationalgeographic.com/environment/article/mining-is-a-polluting-business-can-new-tech-make-it-cleaner>.

²⁸ Reichmuth, Dunn, and Anair, *Driving Cleaner: Electric Cars and Pickups Beat Gasoline on Lifetime Global Warming Emissions*, Union of Concerned Scientists, July 2022. <https://www.ucsusa.org/sites/default/files/2022-09/driving-cleaner-report.pdf>



Life cycle global warming emissions are significantly lower for EVs than for gasoline cars or trucks when considering manufacturing and usage, despite higher battery-manufacturing emissions for the EV.

This analysis looked at the full lifecycle of the fuels needed for electric and gasoline vehicles by looking at several variables, including: raw mineral extraction for fuel, emissions from power plants, efficiency of vehicles, oil extraction at the well, oil refining, and combustion of the vehicle's engine. This analysis found that when considering fueling of vehicles, everywhere in the United States, driving the average EV has lower emissions than driving the average new gasoline vehicle.²⁹ Further, the analysis found that driving an average EV in the United States was equivalent to driving a gasoline car that got 91 miles per gallon in terms of greenhouse gas emissions. And, the emissions reductions and air quality benefits from EVs will continue to improve as more and more of the electricity that charges them comes from renewable resources.³⁰

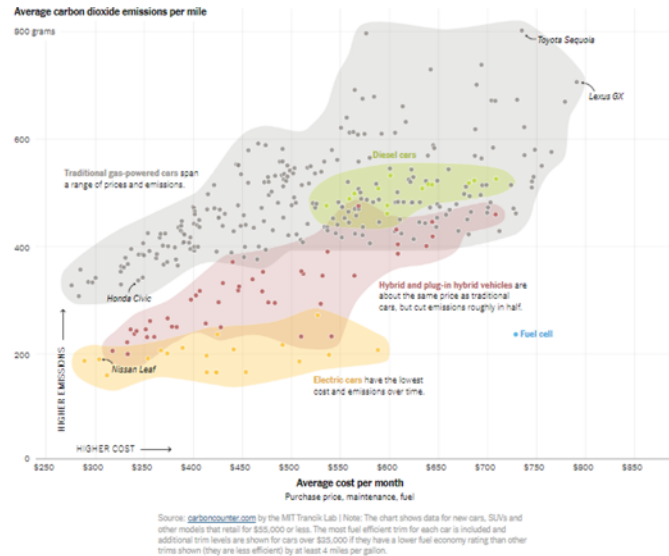
Experts at MIT evaluated the different vehicles both in terms of emissions as well as affordability.³¹ The good news is that electric cars, followed by plug-in hybrids and conventional hybrids, are generally far cleaner *and* more affordable in terms of the average consumer. The researchers at MIT have further stated that "it's difficult to find a comparison [between gasoline vehicles and electric vehicles] in which EVs fare worse than internal combustion."³² The current technologies are cleaner and becoming even more affordable – and this trend is expected to continue.

²⁹ *Id.*

³⁰ *Id.*

³¹ Penney, *Electric Cars are Better for the Planet—and Often Your Budget, Too*, New York Times, January 15, 2021, <https://www.nytimes.com/interactive/2021/01/15/climate/electric-car-cost.html>

³² Moseman and Paltsev, *Are Electric Vehicles Definitely Better for the Climate than gas-powered cars?* October 13, 2022, <https://climate.mit.edu/ask-mit/are-electric-vehicles-definitely-better-climate-gas-powered-cars>



An analysis by Reuters using the Argonne National Laboratory's Greenhouse Gases, Regulated Emissions and Energy Use in Technologies (GREET) model considered the well-to-wheel emissions of an electric vehicle.³³ The analysis shows that while production of an electric vehicle emits 15 carbon dioxide g/mile more than the production of a gasoline vehicle, EVs still emit far less carbon dioxide than their gasoline counterparts of their lifetime, due to the emissions benefits of electricity as a fuel source as opposed to gasoline. Even charging an electric vehicle using only a coal-powered electric grid would still reduce emissions by half a million grams of carbon dioxide a year compared to a gasoline vehicle. Reuters estimates that a driver would have to drive approximately 13,500 miles on their vehicle as the point where EVs well-to-wheel emissions are cleaner than gasoline vehicles. Considering the average vehicle in the United States is driven around 11,400 miles per year,³⁴ this means that just after a year of vehicle ownership an EV will be cleaner than a gasoline vehicle when considering the vehicle lifecycle.

5. Please provide an example of where you believe there is common ground among all witnesses who testified before the Committee for this hearing.

During the hearing on April 18, 2023, it appeared that all witnesses were in agreement that it is vitally important to bring jobs and the zero-emission vehicle supply chain to the United States.

³³ Lienert, *Analysis: When Do Electric Vehicles Become Cleaner than gasoline cars?* Reuters. July 7, 2021. <https://www.reuters.com/business/autos-transportation/when-do-electric-vehicles-become-cleaner-than-gasoline-cars-2021-06-29/>

³⁴ US Department of Energy Alternative Fuels Data Center, *Maps and Data- Average Annual Vehicle Miles Traveled by Major Vehicle Category*. February, 2020. <https://afdc.energy.gov/data/10309>

Senator Sullivan asked the witnesses about the Administration's desire to have America to source the critical minerals that we will need for electric vehicles. The panelists all agreed that we can and should bring these supply chains to the United States. Further, all of the witnesses also agreed on the importance of sustainability and cleaner vehicles to reduce NOx and other harmful emissions, and the need to invest in the nation's charging infrastructure and grid resiliency.

All of these areas of agreement can be achieved through common sense policies, including EPA's vehicle emissions standards.

6. Is there anything else that you would like to provide the Committee that was not included in your testimony or discussed during the hearing?

While it is ultimately EPA's main responsibility to set standards that are feasible and deliver clean air and environmental protections, we recognize that there were other considerations raised by the Minority witness that should be addressed in this response.

Supply Chain Considerations

The market is moving quickly toward more and more zero-emission vehicles and manufacturers have already made commitments to transition their fleets in the next decade. For example, there were only 20 zero-emission truck models available in 2019, but that number grew to 544 available models three years later.³⁵ And there are now over 90 models of light-duty electric vehicles available for drivers to purchase³⁶ with at least another 61 models forthcoming.³⁷ Additionally, state-level vehicle emissions policies, like the Advanced Clean Trucks and Advanced Clean Cars II rules, work complementary to federal-level efforts and help increase model availability and affordability.

While it is true that there are some near-term supply chain issues, those near-term constraints must be viewed in context. First, supply chain constraints can affect vehicles of all types, not just electric vehicles. The global chip shortage has impacted zero-emission vehicles and gas-powered vehicles alike, and recent increases in global oil prices have also uniquely impacted those polluting vehicles. There is reason to believe that today's zero-emission vehicle supply chain constraints – including critical mineral concerns – will be resolved in time to comply with these future standards.

Economic Considerations

Consumers are expected to benefit from significant cost savings on operating costs over the lifetime of a vehicle that meets the proposed light- and medium-duty standards. For all vehicles

³⁵ Environmental Defense Fund: EV Market Uptake Report (2022):

https://blogs.edf.org/climate411/files/2022/04/electric_vehicle_market_report_v6_april2022.pdf

³⁶ Alliance for Automotive Innovation, *Get Connected: Electric Vehicle Quarterly Report*. Fourth Quarter, 2022.

<https://www.autosinnovate.org/posts/papers-reports/Get%20Connected%202022%20Q4%20Electric%20Vehicle%20Report.pdf>

³⁷ EV Hub, *Automakers Dashboard*, Atlas Public Policy. <https://www.atlasevhub.com/materials/automakers-dashboard/>

meeting the standards, these savings include fuel savings and, for battery electric vehicles, maintenance, and repair savings as well. In fact, EPA is estimating that drivers will save up to \$13,000 during the initial ownership of an electric vehicle compared to its gas-powered counterpart.³⁸

For heavy-duty vehicles, the savings on fuel and maintenance costs outweigh any incremental upfront costs associated with adopting zero-emission truck technology, and the economics will only continue to improve due to advances in battery technology and increased zero-emission vehicle production. In fact, many electric trucks and buses will be cheaper than gas-powered vehicles thanks to the investments from the Inflation Reduction Act.³⁹ And a growing set of state, federal, and utility incentives from the bipartisan infrastructure bill and other federal and state programs will further reduce zero emission vehicle costs.

Grid Considerations

EVs are not a problem, but are a solution to support the grid, and policies that advance EV adoption are not in conflict with efforts to continue to move to renewable energy, but a means to achieve those goals and improve reliability.

The grid is built for the most demanding hour of the year and every other hour there is excess capacity. We can employ commonsense policies, such as encouraging EV owners to charge when electricity is plentiful and cheap and deploy technologies that allow EV batteries to not only draw power from the grid, but also to provide back-up power to homes and supply the grid during times of severe stress.⁴⁰ Additionally, it will be nearly a decade from now before these standards fully kick in and utility providers are confident that they are able to build a grid that meets today's demands and the demands of the future.

Senator Kelly:

1. **As we look towards the future of cleaner vehicles, it's important we think about how to maximize their benefits for consumers and our climate. One key metric that stands out for this purpose is efficiency. Higher levels of efficiency mean that an EV can travel further while using less energy, enabling electric vehicles to travel longer distances with smaller batteries and less demand on the grid. What are some of the important environmental benefits of more energy efficient EVs that can travel further distances with smaller batteries and less energy from the grid?**

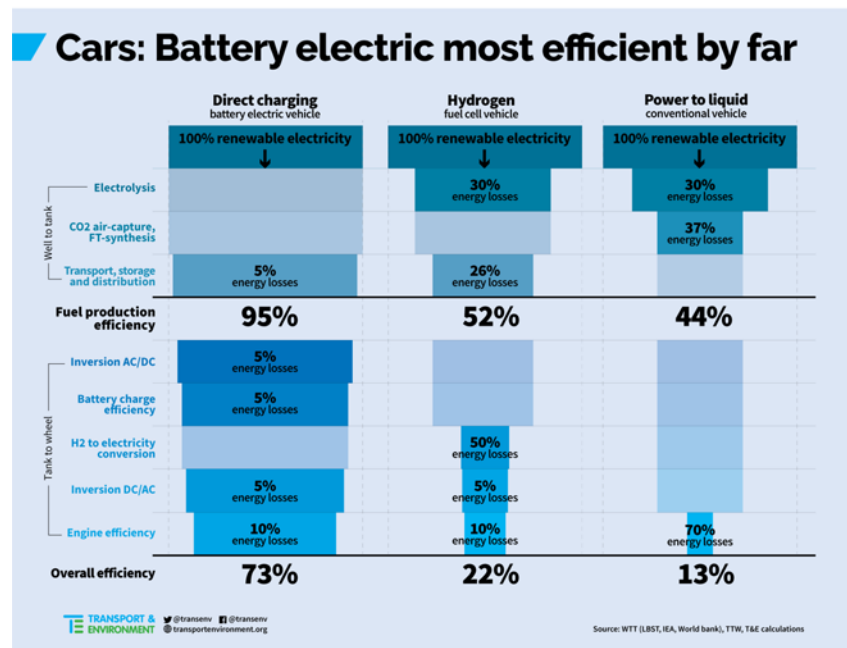
It is first important to note that electric vehicles (EVs) are already three to four times more efficient than a comparable gasoline vehicle. The US Department of Energy states that EVs

³⁸ EPA Factsheet on Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles (2023): <https://www.epa.gov/system/files/documents/2023-04/420f23009.pdf>

³⁹ RMI: The IRA Will Help Electrify Heavy-Duty Trucking (2022): <https://rmi.org/inflation-reduction-act-will-help-electrify-heavy-duty-trucking/>

⁴⁰ NRDC Blog: "How Electric Cars and Trucks Improve Grid Reliability" (2022): <https://www.nrdc.org/bio/max-baumhefner/how-electric-cars-and-trucks-improve-grid-reliability>

convert 77% of the energy from the electricity used to power them⁴¹, while a gasoline vehicle only converts about 12-30% of the energy from gasoline to operate.⁴² Gasoline energy is lost due to engine and driveline inefficiencies, while EVs utilize regenerative braking to “re-capture” some of the energy used to operate the vehicle and “return” it to the battery, while also having fewer moving parts. A recent study by the University of Delaware found that around 38% of drivers in the United States could meet all of their driving needs with smaller (and more efficient vehicles).⁴³ A graphic by Transport & Environment is shown below demonstrating the differences.⁴⁴



⁴¹United States Department of Energy, *Where the Energy Goes: Electric Cars*.

<https://www.fueleconomy.gov/fcg/atv-ev.shtml>

⁴²United States Department of Energy, *Where the Energy Goes: Gasoline Vehicles*.

<https://www.fueleconomy.gov/fcg/atv.shtml>

⁴³Bell, *Get Over Your Range Anxiety: Study Shows Small EV Batteries Meet Most Drivers' Needs*, Carscoops. March 3, 2023. <https://www.carscoops.com/2023/03/smaller-batteries-lower-range-may-actually-be-better-for-large-portion-of-ev-drivers/>

⁴⁴Shahan, *This Stunning Chart Shows Why Battery Electric Vehicles Win*, CleanTechnica, June 10, 2020.

<https://cleantechnica.com/2020/06/10/this-stunning-chart-shows-why-battery-electric-vehicles-win/>

However, there are benefits in making electric vehicles more efficient in battery size and vehicle size. In this case, efficiency of an EV is considered how much power or electricity is needed to get the vehicle a certain distance. More efficient vehicles tend to have smaller battery size than less efficient vehicles. The smaller the battery size, the fewer critical minerals are needed to produce the battery, reducing the amount of extraction of minerals that are needed. As discussed in the response to Senator Carper's questions, extraction of minerals to produce an electric vehicle is higher than a gasoline vehicle, so reducing the amount of minerals needed to produce an electric vehicle battery would reduce this environmental impact and create even larger well-to-wheel and lifecycle benefits compared to gasoline vehicles.

The efficiency of electric vehicles can also affect the miles that the vehicle will get per kWh of energy. This affects the amount of electricity needed to recharge the vehicle. A recent review of current popular electric vehicles on the market found that the average efficiency of these vehicles is approximately 3.1 miles per kilowatt hours. But the range of these efficiencies are wide—from 2.0 miles/kWh (the Ford Lightning Electric) to 4.2 miles/ kWh (the Lucid Air).⁴⁵ The lower the amount of electricity that is needed to recharge electric vehicles, the lower the total upstream emissions from charging an electric vehicle. Additionally, more efficient vehicles will be able to charge their batteries quicker than less efficient vehicles due to battery sizes, which may help to reduce the electricity needed to recharging electric vehicles.

2. EPA's recently proposed GHG emissions standards for light, medium, and heavy-duty vehicles will accelerate our nation's transition to zero-emission vehicles, helping to spur private-sector innovation, tackle climate change and save drivers money. However, as stands, our federal policies do little to promote the adoption of more energy efficient clean vehicles. How could GHG and fuel-economy standards that incorporate EV efficiency help to promote greater levels of efficiency across the industry as it electrifies?

Strong policies that make vehicles cleaner (like EPA's vehicle tailpipe emission standards) and more efficient (such as DOT's fuel economy and fuel efficiency standards) are essential to a safer and healthier future. These policies are also incredibly effective and are complementary. As a result of the past five decades of federal vehicle emission and fuel economy standards, vehicles in the United States are getting more efficient and less polluting. More efficient vehicles mean fewer trips to the gas station and more money in drivers' pockets and DOT's fuel economy improvements have saved more than two trillion gallons of gasoline since 1975, enough to run every car and light truck in the U.S. for more than 15 years.⁴⁶

Until today, most of the gains in fuel efficiency and reductions in tailpipe pollution have come from improving the performance of gasoline-powered vehicles through technologies

⁴⁵ Harto, Blog: *Can the Grid Handle EV's? Yes!*, Consumer Reports, May 10, 2023.

<https://advocacy.consumerreports.org/research/blog-can-the-grid-handle-evs-yes/>

⁴⁶ NRDC Report: *The Real Road to Energy Independence* (2022): <https://www.nrdc.org/sites/default/files/energy-independence-clean-car-standards-fs.pdf>

such as direct injection, cylinder deactivation, engines that turn off at stops, and transmissions with more speeds. While there are still a lot of efficiency gains to be had from such improvements, we see that the market is shifting towards electrification, which is a far more efficient form of the vehicle technology on the road. Strong clean vehicle standards from the EPA will help lock in and accelerate the climate and public health benefits that can result from cleaner and more efficient vehicles and zero-emission vehicles.

3. The Biden Administration has set a clear and ambitious goal of having 50 percent of all new vehicle sales be electric by 2030. While I support this goal, I also recognize the many challenges that lie ahead as EV adoption increases substantially. How would having more energy efficient EVs on the market help us to meet the goal of rapid EV deployment while simultaneously lowering upstream emissions and the impact on global supply chains for critical minerals?

Just as some fossil-fuel powered vehicles get higher mileage per gallon, thus reducing demand for gasoline, different EV designs get different miles per kilowatt-hour. More efficient EVs can travel the same distance with smaller batteries, and therefore, less battery materials, than less efficient EVs.

Since batteries heavily influence the cost of electric vehicles, more efficient electric vehicles with smaller battery sizes will help to make EVs more affordable in terms of upfront costs. The good news is that battery prices are continuing to decrease, and incentives from the federal government under the Inflation Reduction Act will help to continue to reduce this upfront cost.⁴⁷ Producing smaller, more efficient electric vehicles will further reduce these upfront costs for drivers, helping to increase the deployment of these cars throughout the United States.

More efficient vehicles with smaller batteries will also reduce the amount of minerals that are extracted and refined. This will reduce the upstream emissions from this portion of the supply chain while also reducing the number of minerals needed to electrify fleets. Reducing the amount of minerals each vehicle requires will ensure that mineral supply can keep pace with demand. In fact, one study found that reducing the size of EV batteries could reduce lithium demand by as much as 42 percent in 2050.⁴⁸

More efficient vehicles will also reduce the amount of electricity that is needed to recharge a vehicle from empty to full. Since electricity comes from the grid, which is still heavily powered by fossil fuels, reducing the amount of energy needed to charge a vehicle will therefore reduce the amount of emissions from the powerplant—known as upstream emissions.

⁴⁷ US Department of Energy. *Electric Vehicle Battery Pack Costs in 2022 Are Nearly 90% Lower than in 2008, according to DOE Estimates*. January 9, 2023. <https://www.energy.gov/eere/vehicles/articles/fotw-1272-january-9-2023-electric-vehicle-battery-pack-costs-2022-are-nearly>

⁴⁸ UC Davis. *Achieving Zero Emissions with More Mobility and Less Mining*. January 2023. https://www.climateandcommunity.org/_files/ugd/d6378b_3b79520a747948618034a2b19b9481a0.pdf

Senator MARKEY. Thank you, Ms. Harris, very much.

Next, we are going to hear from Chris Harto from Consumer Reports.

**STATEMENT OF CHRIS HARTO, SENIOR ENERGY POLICY
ANALYST, CONSUMER REPORTS**

Mr. HARTO. Good afternoon, Chair Markey, Ranking Member Ricketts, and members of the subcommittee. My name is Chris Harto, and I am a Senior Sustainability Policy Analyst at Consumer Reports.

I thank the committee for inviting CR to testify today in support of the proposed EPA greenhouse gas standards for model years 2027 through 2032 and on the benefits that they will bring to American consumers.

CR is a nonprofit, nonpartisan organization. One of the things that CR is best known for is testing cars. Every year, our testers drive about half a million miles to put new cars through their paces, and we work with policymakers like you to advance policies for safer and cleaner cars.

For decades, Federal greenhouse gas emissions standards have played a critical role in reducing overall emissions from the transportation sector, while encouraging automakers to innovate and offer increased clean vehicle options for consumers.

The proposed EPA standards, if enacted, would bring cleaner, cost-saving transportation technologies to consumers faster. The rule will save consumers money while reducing spending on healthcare tied to air pollution and disaster recovery tied to greenhouse gas emissions.

I have three main points I would like to make based on CR's analysis. First, EPA's standards are achievable. Second, consumer demand for EVs is far outpacing supply. Third, EVs save consumers money.

The proposal for light duty vehicle standards is ambitious, but achievable. EPA's analysis is that EVs are likely to be the most cost-effective compliance pathway, but not the only option for automakers. Automakers can also use a mix of improvements in internal combustion fuel efficiency, conventional hybrids, plug-in hybrids, and even hydrogen fuel cell vehicles to comply.

EPA estimated that while an EV-only compliance pathway would require about two-thirds of vehicles sold to be EVs by 2032, industry is already on track to deliver around 50 percent EV sales by 2030, according to commitments made by automakers.

Further, consumer challenges, such as charging infrastructure and affordability will only continue to improve due to the unprecedented investments from the Bipartisan Infrastructure Law and the Inflation Reduction Act, which provide funding for charging infrastructure and consumer tax credits, respectively.

Consumers want EVs. Consumer demand for EVs has been soaring, increasing 350 percent between 2020 and 2022. Unfortunately, automakers have not been keeping up. There are now around 45 percent of consumers who say they would definitely buy an EV for every EV being manufactured. Meanwhile, 30 percent of new car buyers are not even considering a conventional non-hybrid vehicle.

CR estimates that an EV-only compliance pathway would result in the production of enough EVs for approximately 25 percent of Americans to own one by the end of 2032. A 2022 CR survey found that already, 36 percent of American adults were definitely or seriously considering an electric vehicle if they were to buy a vehicle today, indicating the consumer demand may already exceed what is needed to comply with these standards.

Despite the rapid growth in consumer demand, people can not buy vehicles that do not exist. Consumers who want an EV right now often have to deal with long waitlists and dealer markups. Automakers are making investments to improve supply, but unfortunately, the growth and supply has still been lagging. EPA's proposal should help automakers catch up.

EVs are cheaper to own. A 2020 analysis by CR found that EVs are cheaper to own than comparable gasoline vehicles, even when factoring in higher purchase prices. EVs save an average of 60 percent on fuel and 50 percent on repairs and maintenance. This translates to between around \$6,000 and \$10,000 over the life of the vehicle, even factoring in higher prices.

Higher purchase prices, however, are likely to be temporary. As of January, automakers and battery manufacturers already plan to invest \$210 billion in U.S. manufacturing by 2030. A 2022 analysis by ICCT found that EVs are rapidly approaching cost parity with conventional vehicles, even with a range of over 300 miles.

In conclusion, EPA's proposed light duty vehicle standards will hit the accelerator, helping to drive automakers to catch up to consumer demand for cleaner vehicles. We see these rules as a win-win for consumers and the climate, putting over a trillion dollars back into consumers' pockets while delivering massive reductions in air pollution and greenhouse gas emissions.

[The prepared statement of Mr. Harto follows:]



**Testimony of Christopher Harto
Policy Analyst, Sustainability Policy
Consumer Reports**

**Before the
Senate Committee on Environment & Public Works,
Subcommittee on Clean Air, Climate, and Nuclear Safety**

**Hearing on
“Cleaner Vehicles: Good for Consumers and Public Health”**

April 18, 2023

Thank you Chair Markey, Ranking Member Ricketts, and members of the Clean Air, Climate, and Nuclear Safety sub-Committee of the Senate Environment and Public Works Committee, for inviting Consumer Reports (CR) to testify in support of the benefits that the proposed Environmental Protection Agency (EPA) Greenhouse Gas (GHG) Standards for Model Years (MY) 2027-2032 will bring to American consumers. .

1. Summary

The proposed EPA GHG Standards for MYs 2027-2032, if finalized, would bring more cleaner, cost-saving transportation technologies to consumers. The rule would save consumers money on fueling costs while reducing spending on healthcare tied to air pollution, and reducing spending on climate disaster recovery tied to greenhouse emissions.¹ These cost savings are particularly important for overburdened communities, such as low-income communities.

In order to reduce emissions, policies that help clean vehicles such as electric vehicles (EV) reach consumers as quickly as possible are vital. By giving consumers more options for cleaner, cost-saving transportation technologies, we empower them to make decisions that will benefit their wallets—and lower emissions.

Investments from the Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Law (BIL) will address challenges consumers face in adopting EVs more widely, such as charging infrastructure and affordability. The recent EPA proposal, in harmony with the IRA and BIL, will support the necessary transition to a cleaner transportation sector.

2. About Consumer Reports

Consumer Reports (CR) is an independent, nonprofit and nonpartisan organization that works with consumers to create a fair and just marketplace. Known for its rigorous product testing and ratings, CR also advocates for laws and corporate practices that are beneficial for consumers. It surveys millions of Americans every year, reports extensively on the challenges and opportunities facing today's consumers, and provides ad-free content and tools to 6 million members across the United States. CR is dedicated to amplifying the voices of consumers to promote safety, digital rights, financial fairness, and sustainability.

¹ *Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles*, EPA, 2023, <https://www.epa.gov/system/files/documents/2023-04/lmdv-multi-pollutant-emissions-my-2027-nprm-2023-04.pdf>

3. Introduction

CR's surveys and analyses show that consumers care about their impact on the environment and want access to cleaner and less polluting technology.² Air pollution and greenhouse gas (GHG) emissions have adverse impacts on the health of consumers, the environment, and climate. GHG emissions are contributing to extreme weather events such as extreme heat, flooding, and drought. Criteria pollutants such as ozone and particulate matter cause health issues such as respiratory diseases, lung cancer, pre-term births, and neurological damage. These issues disproportionately affect overburdened communities such as low income communities and communities of color.

These impacts can show up in various ways that will increase costs for consumers, not only for fuel and energy use, but for other consumer costs, such as healthcare and insurance. Providing consumers with cleaner and more energy-efficient technologies can dramatically lower these costs, and doing so will enable them to make purchasing decisions that save them money. Cost savings are especially critical for low-income households which spend a disproportionate amount of their income on energy bills.³

Transportation accounts for 28% of GHG emissions⁴—more than any other sector in the US. EPA's greenhouse gas standards for vehicles offer a highly cost-effective way to drastically reduce these emissions. These standards have already been extremely successful. Over the past two decades, clean car standards which include EPA's GHG standards, harmonized with the Department of Transportation (DOT) National Highway Traffic Safety Administration's (NHTSA) Corporate Average Fuel Economy (CAFE) standards, have delivered \$7,000 in lifetime fuel savings and a 30% reduction in greenhouse gas emissions from the average new vehicle. At the same time, vehicles became safer, larger, more powerful; but, most impressively, all of those improvements were delivered with no inflation-adjusted increase in vehicle prices.⁵

In December 2021, EPA finalized GHG standards for MY23-26. CR estimates that those standards will save consumers an average of \$2,400 over the lifetime of new vehicles purchased in MY26.⁶ EPA's latest proposal for standards for MY27-32, released last week, builds on this

² *More Americans Would "Definitely" Get Electric Vehicles*, Consumer Reports, July 7, 2022, https://advocacy.consumerreports.org/press_release/more-americans-would-definitely-get-electric-vehicles/

³ *Low-Income Households, Communities of Color Face High "Energy Burden" Entering Recession*, ACEEE, 2020, <https://www.aceee.org/press-release/2020/09/report-low-income-households-communities-color-face-high-energy-burden>

⁴ *Sources of Greenhouse Gas Emissions*, EPA, 2021, <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>.

⁵ *Vehicle Price Trends, Fuel Economy and Safety Improvements Come Standard*, Consumer Reports, February 21, 2023, <https://advocacy.consumerreports.org/wp-content/uploads/2023/02/CR-Vehicle-Price-Trends-Feb-21-2023.pdf>.

⁶ *Press Release, Biden administration follows through with improved greenhouse gas emissions standards – a win for consumers and the climate*, Consumer Reports, December 20, 2021, https://advocacy.consumerreports.org/press_release/biden-administration-follows-through-with-improved-greenhouse-gas-emissions-standards-a-win-for-consumers-and-the-climate/.

momentum to supercharge the consumer savings and emissions reductions. Due to the rapidly improving economics of EVs, EPA estimates that these new standards will deliver another \$12,000 in consumer savings from the average new vehicle in 2032.⁷

4. The Proposed EPA Greenhouse Gas Standards for Model Year 2027-2032 are Achievable

EPA's proposal for MY27-32 light-duty vehicle greenhouse gas standards are strong, achievable, technology-neutral performance standards. EPA's analysis found that electric vehicles (EVs) are likely to be the most cost-effective compliance pathway to meet these standards—but not the only option—for automakers. EPA estimated that an EV-only compliance pathway would require 67% of vehicles sold to be EVs by 2032. However, automakers can also use a mix of improvements in internal combustion fuel efficiency, conventional hybrids, plug-in hybrids (PHEV), and even hydrogen fuel cell electric vehicles (FCEV) to comply with these standards.

EPA's analysis of existing automaker EV commitments shows that the industry was already on track to deliver around 50% EVs by 2030. These rules simply reflect a slight boost to the trajectory the industry was already telling its shareholders it was on, made possible by the historic investments in the Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) of 2022.

Further, investments from the IRA and BIL will address challenges faced by consumers in adopting EVs more widely, such as charging infrastructure and affordability. The IRA allocates \$370 billion in climate and clean energy investments to expand tax credits and incentives to deploy more clean vehicles, support domestic EV supply chains, and build out EV charging infrastructure across the country. And the BIL provides \$7.5 billion to expand public charging infrastructure across the US: \$5 billion of that is for a nationwide network of 500,000 EV charging stations, and \$2.5 billion is for publicly accessible alternative fuel infrastructure including EV charging stations. The IRA and BIL, in harmony with the recent EPA proposal, will support the necessary transition to a cleaner transportation sector.

CR estimates that an EV-only compliance pathway would result in the production of enough EVs for approximately 25% of Americans to own one by the end of 2032. In a 2022 nationally representative survey of 8,027 US adults, CR found that 36% of Americans were already “definitely” or “seriously considering” an electric vehicle if they were to buy or lease a vehicle today, indicating that consumer demand may already exceed what is needed to comply with these standards.⁸

⁷ *White House Fact Sheet: Biden-Harris Administration Proposes New Standards to Protect Public Health that Will Save Consumers Money, and Increase Energy Security*, April 12, 2023, <https://www.whitehouse.gov/briefing-room/statements-releases/2023/04/12/fact-sheet-biden-harris-administration-proposes-new-standards-to-protect-public-health-that-will-save-consumers-money-and-increase-energy-security/>

⁸ *More Americans Would “Definitely” Get Electric Vehicles*, Consumer Reports, July 7, 2022, https://advocacy.consumerreports.org/press_release/more-americans-would-definitely-get-electric-vehicles/

5. Consumer Benefits of EVs

Consumers are rapidly recognizing the significant benefits that EVs can provide. At an average gas price of \$3.50/gallon, we estimate that an electric SUV would deliver an average of \$1,700 in fuel and maintenance savings every year.⁹ A 2020 analysis by CR found that the most popular EVs were already cheaper to own than the most popular and highest-rated gasoline vehicles in their class, even factoring in higher purchase prices. These savings were delivered, despite higher purchase prices, due to EVs saving an average of 60% on fuel and 50% on repairs and maintenance.¹⁰ On average, the study found that EVs sold at that time would save consumers around \$6,000 to \$10,000 over the lifetime of the vehicle. Importantly, the study found that while EVs were usually cheaper to own for a first owner who drove the vehicle for the first six years, the largest chunk of the savings flowed to a second owner who purchased the vehicle used. This is because used vehicle buyers will pay less of a premium to purchase an EV, while seeing similar fuel savings, and even greater maintenance cost savings due to increasing maintenance requirements for older vehicles.

While some consumers have expressed concerns about the cost of battery replacements, the data on existing EVs to date has found that they are usually rare.¹¹ Most EVs today come with an 8 year, 100,000 mile warranty and automakers are designing their EV batteries to last at least 15-20 years.¹² EPA's GHG rule will apply the 8 year/80,000 mile warranty requirement for "major emissions control components" from the Clean Air Act Section 207 to electric vehicle powertrains. They also include further requirements on battery durability and the inclusion of consumer facing battery state-of-health monitoring to allow consumers to track the health of their EV battery.

Cost savings are not the only reason EVs are becoming so popular. EVs also offer a more satisfying driving experience with instant torque and smooth, silent acceleration. In CR's latest satisfaction ratings, 4 of the top 10 vehicles have a plug, achieving scores similar to popular sports cars including the Chevrolet Corvette, Porsche 911, and Mazda Miata.¹³ Almost as importantly, not a single plug-in vehicle made it onto the list of top 10 least satisfying vehicles.

⁹ *New Consumer Reports analysis shows rising gas prices ramp up savings for EV owners*, Consumer Reports, March 10, 2022, https://advocacy.consumerreports.org/press_release/new-consumer-reports-analysis-shows-rising-gas-prices-ramp-up-savings-for-ev-owners/

¹⁰ *Press Release, New analysis from CR finds that the most popular electric vehicles cost less to own than the best-selling gas-powered vehicles in their class*, Consumer Reports, October 8, 2020, https://advocacy.consumerreports.org/press_release/new-analysis-from-cr-finds-that-the-most-popular-electric-vehicles-cost-less-to-own-than-the-best-selling-gas-powered-vehicles-in-their-class/.

¹¹ *New Study: How Long Do Electric Car Batteries Last?* Recurrent, 2023, <https://www.recurrentauto.com/research/how-long-do-ev-batteries-last>

¹² *How Long Do Electric Car Batteries Last?* Autotrader, March 2023, <https://www.autotrader.com/car-tips/how-long-do-electric-car-batteries-last>

¹³ *The Cars People Love Most*, Consumer Reports, February 2, 2023, <https://www.consumerreports.org/cars/car-reliability-owner-satisfaction/most-satisfying-cars-on-the-market-car-owner-satisfaction-a8149304159/>.

6. Key Drivers of the EV Market

Because of these performance and ownership cost benefits, consumer demand for EVs has been soaring, increasing by 350% between 2020 and 2022. Unfortunately, automakers have not kept up. There are now 45 consumers for every EV being manufactured who say they would “definitely buy” an EV if they were to buy or lease a new vehicle today.¹⁴ The end result of this mismatch between supply and demand is that consumers who do want an EV right now have to deal with a tangled mess of long waitlists and dealer markups. Automakers are making investments to improve supply, but unfortunately the growth in supply has been lagging the growth in demand.

We see four major trends that will likely make EV demand outpace EV supply: 1) purchase cost for EVs is declining, 2) infrastructure is expanding, 3) consumers are gaining more experience with EVs, and 4) automakers are investing in new models and increased production. These trends tend to reinforce one another in a virtuous cycle.

Initial purchase cost is currently one of the top barriers to EV ownership.¹⁵ Yet a combination of technological advancements, consumer demand, automaker efficiencies, economies of scale, and government tax incentives are helping to drive down the costs of EVs. Many auto industry analysts and observers have estimated that cost parity between EVs and conventional gasoline vehicles will be achieved sometime this decade. Recent analysis from the International Council on Clean Transportation (ICCT) estimated that even without any tax incentives, EVs with 300 miles of range per charge will achieve cost parity in all light-duty vehicle classes before 2030.¹⁶

What’s more, the IRA will offer tax credits of up to \$7,500 for the purchase of new EVs that meet certain manufacturing, vehicle pricing, buyer income, and critical minerals requirements. A separate study from the ICCT estimated that these tax credits would make the average new qualifying EV cheaper than the average new conventional vehicle no later than 2025, resulting in a large boost in EV demand.¹⁷

Another major barrier to EV adoption is the lack of widespread, reliable charging infrastructure. The BIL provides \$7.5 billion to help deploy EV charging infrastructure throughout the country. Also, as more EVs are sold, there will be more demand for infrastructure—and more revenue generated by it—which will likely help catalyze further private investment. The EPA GHG standards can be especially helpful in solving the chicken-and-egg problem with infrastructure. By guaranteeing that greater numbers of electric vehicles will be manufactured in the coming

¹⁴ *Excess Demand, The Looming EV Shortage*, Consumer Reports, March 2023, <https://advocacy.consumerreports.org/wp-content/uploads/2023/03/Excess-Demand-The-Looming-EV-Shortage.pdf>.

¹⁵ *More Americans Would “Definitely” Get Electric Vehicles*, Consumer Reports, July 7, 2022, https://advocacy.consumerreports.org/press_release/more-americans-would-definitely-get-electric-vehicle/.

¹⁶ *Assessment of Light-Duty Vehicle Cost and Consumer Benefits in the United States in the 2022-2035 Timeframe*, The International Council on Clean Transportation, October 2022, <https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf>.

¹⁷ *Analyzing the Impact of the Inflation Reduction Act on Electric Vehicles Uptake in the United States*, The International Council on Clean Transportation, January 2023, <https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23-2.pdf>.

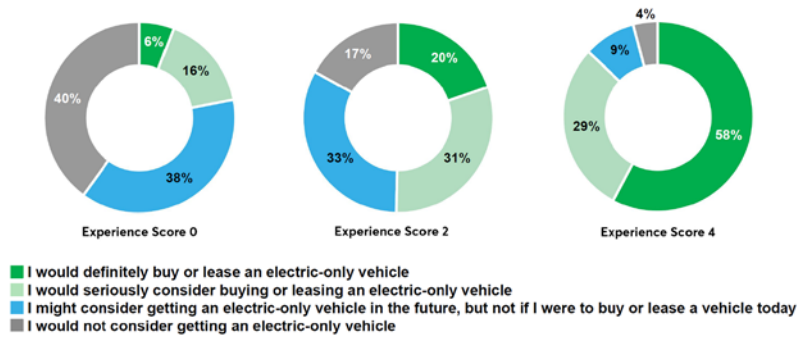
years, the new standards will help give private industry the confidence it needs to invest in infrastructure, knowing that greater demand for reliable charging infrastructure is on the way.

Private corporations are already beginning to see the opportunity that EV charging can provide. Walmart, 7-11, Starbucks, and Subway have all recently announced major EV charging initiatives. As consumers become more confident in the availability and reliability of the charging network, their interest in purchasing an EV is likely to increase.

Direct experience with EVs is one of the strongest, but also most underappreciated drivers of purchase interest. This is illustrated in Figure 1, in which the three pie graphs represent low, medium, and high levels of experience with battery electric vehicles. CR found that consumers with the most direct experience were almost ten times as likely to say they would “definitely buy” an electric vehicle today as consumers with no direct experience (58% vs 6%).¹⁸ More EVs on the road means more opportunities for Americans to gain more direct experience and exposure to EVs. Right now, broad consumer experience with EVs is very limited, but that is likely to change as more people see family, friends, and neighbors bring home their first EV.

Figure 1. Survey Results on EV Demand by Experience with BEVs

Which Statement below BEST describes your thoughts on buying or leasing an electric-only vehicle if you were to buy or lease a vehicle today?



Finally, as purchase interest goes up, automakers are likely to respond by delivering more electric options, in more vehicle classes, and at more price points. We’re already seeing significant growth in the number of EV models that will become available to consumers over the next few years.¹⁹ Many automakers have also significantly boosted their long term EV

¹⁸ *More Americans Would “Definitely” Get Electric Vehicles*, Consumer Reports, July 7, 2022, https://advocacy.consumerreports.org/press_release/more-americans-would-definitely-get-electric-vehicle/

¹⁹ *Automakers Are Adding Electric Vehicles to Their Lineups. Here’s What’s Coming*, Consumer Reports, March 10, 2023,

commitments in recent years, and it seems likely that more will follow suit. As of January 2023, automakers and battery makers plan to invest \$860 billion in the transition to EVs by 2030, including \$210 billion in the U.S, according to an analysis by Atlas Public Policy.²⁰ As automakers deliver more volume, economies of scale and intensified competition for customers will further feed cost declines, which will feed back into the cycle and lead to increased EV demand.

7. Risks to Automakers from Moving Too Slowly

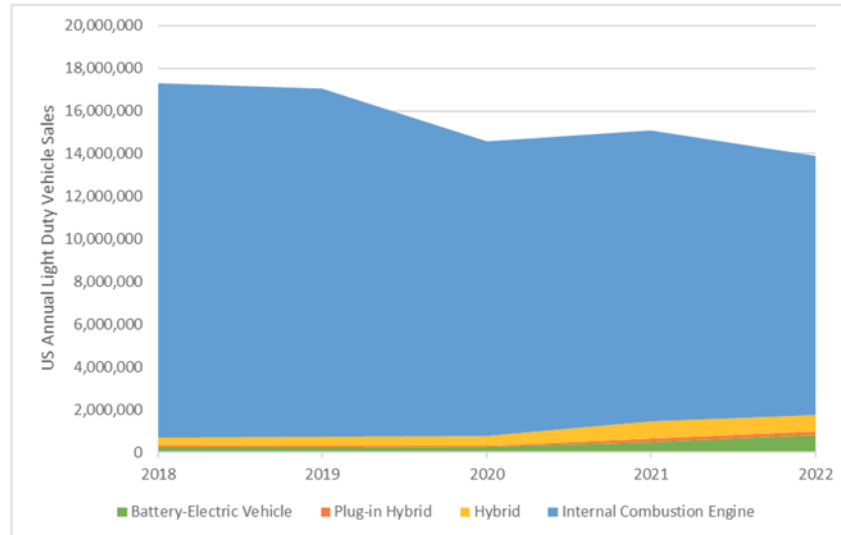
Despite the rapid growth in consumer demand, consumers can't buy vehicles that don't exist. It is critical that automakers rapidly scale up EV production to keep pace with growing demand. It remains unclear how consumers will respond if the supply of EVs is insufficient to meet their demand, but it may prove disastrous for automakers to assume that consumers will buy whatever they build. CR's car buying survey from March and April 2022 found that 30% of licensed drivers who were then in the market to buy or lease a new (and not a used) vehicle were not even considering a conventional, non-hybrid vehicle.²¹ Given the demand dynamics just discussed, it seems unlikely that this number will stop growing anytime soon. Analysis of sales data over the past few years further suggests that demand for Internal Combustion Engine (ICE) vehicles is already declining precipitously. Sales of new ICE vehicles dropped by 26% from 2019 to 2022, while combined sales of BEVs, PHEVs, and conventional hybrids increased by 144%. BEV sales alone increased by 244%.²² This is illustrated in Figure 2 below.

<https://www.consumerreports.org/cars/hybrids-evs/why-electric-cars-may-soon-flood-the-us-market-a9006292675/>.

²⁰ \$210 Billion of Announced Investments in Electric Vehicle Manufacturing Headed for the U.S., Atlas EV Hub, January 12, 2023, https://www.atlasevhub.com/data_story/210-billion-of-announced-investments-in-electric-vehicle-manufacturing-headed-for-the-u-s/.

²¹ *Car Buying: A National Representative Multi-Mode Survey, 2022 Results*, Consumer Reports, May 2022, https://article.images.consumerreports.org/prod/content/dam/surveys/Consumer_Reports_Car_Buying_March_2022.pdf.

²² *Excess Demand, The Looming EV Shortage*, Consumer Reports, March 2023, <https://advocacy.consumerreports.org/wp-content/uploads/2023/03/Excess-Demand-The-Looming-EV-Shortage.pdf>.

Figure 2. US Light-Duty Vehicle Sales by Powertrain Type from 2018-2022

It's not possible to determine what percentage of the reduction in ICE vehicle sales should be attributed to reduced demand vs. what percentage is due to supply chain disruptions caused by the COVID-19 pandemic. However, pandemic-related supply chain issues have now largely been resolved, and they affected EV supply as well, so the picture should soon become clear. Recent data showing both depressed sales of ICE vehicles and rapidly rising dealer inventories suggests that consumer demand for conventional vehicles is unlikely to rebound to anywhere close to prior levels.²³ If these trends continue, automakers that don't rapidly scale up their electrified offerings may find themselves rapidly losing market share, which could hamper their ability to successfully scale up their EV production.

Without standards that keep the industry on a good trajectory to successfully complete a transition to an electrified future, there is much greater risk of the industry running into another situation like 2008. In the few years before 2008, the industry failed to adapt to a rapid shift in consumer demand due to soaring oil prices, got stuck with millions of vehicles consumers no longer wanted, and ended up needing a massive government bailout. These EPA standards can act as a backstop to help ensure that even the laggards in the industry stay on a path that keeps up with rapidly growing consumer demand for electric vehicles.

²³ *February New-Vehicle Inventory Climbed While Sales Grew and Prices Retreated* (A total of 730,000 more vehicles were manufactured than sold between February 2023 and February 2022), Cox Automotive, March 16, 2023, <https://www.coxautoinc.com/market-insights/new-vehicle-inventory-february-2023/>.

8. Light-Duty Standards Summary

EPA's proposed GHG light-duty standards for model year 2027-2032 will hit the accelerator, helping to drive automakers to catch up to consumer demand for cleaner vehicles. We see these rules as a win-win for consumers and the climate, putting over \$1 trillion back into consumers pockets, while delivering massive reductions in air pollution and GHG emissions.²⁴

9. Heavy-Duty Vehicle Proposal

Under EPA's proposed "Greenhouse Gas Standards for Heavy-Duty Vehicles - Phase 3", which were announced at the same time as those for light-duty vehicles, manufacturers must reduce the total amount of greenhouse gas emissions from all new heavy-duty vehicles sold in the U.S. starting in model year 2028. Together with the light duty vehicle standards discussed above the EPA projects that the proposed standards would avoid nearly 10 billion tons of CO₂ emissions, and notes that this is especially significant for communities that have faced the greatest burden of poor air quality.

These rules are critical in reducing GHG from one of the highest polluting subsectors of the transportation market, and they are even more critical in reducing harmful air pollution in communities most impacted by heavy duty vehicle traffic. Due to historically discriminatory policies such as redlining, overburdened communities are disproportionately located in areas near ports, freeways, and high-traffic corridors. Transitioning the vehicles going through these corridors to zero-emission will benefit the communities living around through reduced air pollution and improved air quality.

A recent investigation by CR and the Guardian²⁵ on the rapid expansion of large Amazon warehouse facilities across the United States showed that these warehouse facilities are disproportionately built in communities of color, and low income communities. This further increases the air pollution these communities are exposed to due to medium and heavy duty vehicle traffic to and from the warehouses. EPA's heavy duty rule will help to mitigate air pollution in these communities, protecting the health of these vulnerable communities and reducing public and private spending on health.

²⁴ *Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles*, EPA, 2023, <https://www.epa.gov/system/files/documents/2023-04/ldv-multi-pollutant-emissions-my-2027-nprm-2023-04.pdf>

²⁵ *When Amazon Expands, These Communities Pay the Price*, Consumer Reports, 2021, <https://www.consumerreports.org/corporate-accountability/when-amazon-expands-these-communities-pay-the-price-a2554249208/>



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Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

Executive Summary

Up-front purchase price is only part of the cost consumers pay to own their vehicle. Over the lifetime of a conventional gas-powered vehicle, fuel and maintenance costs can add up to even more than the original purchase price. While electric vehicles (EVs) typically have higher up-front purchase prices, they can save consumers a lot on operating expenses. This study relies on new data on electric vehicle depreciation rates and maintenance and repair costs, along with real world average vehicle prices, to estimate how much today's most popular EVs can save consumers when compared with similar ICE vehicles.

New data obtained by CR from ALG, a data and analytics subsidiary of automotive pricing and information website TrueCar, shows that when adjusted for federal purchase incentives, both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) are expected to depreciate at the same rate as ICE vehicles in the same class over the first five years of ownership. In addition, new data extracted from recent Consumer Reports reliability surveys shows that both BEV and PHEV drivers are saving 50 percent on their repair and maintenance costs, when averaged over a typical vehicle lifetime.

Based on average driving habits, fuel costs for BEVs were estimated assuming mostly home charging and an estimated six fast-charging sessions required per year for BEVs with a range of 250 miles. Overall, BEVs were estimated to save consumers about 60 percent on fuel costs compared with the average vehicle in their class. Fuel costs were also analyzed by state, with the majority of states falling within 10 percent of the national average.

The nine most popular EVs on the market under \$50,000 were compared to (1) the best-selling, (2) the top-rated, and (3) the most efficient vehicles in their class. For six of the nine EVs analyzed, the first-owner ownership costs are estimated to be lower than those of all three comparable ICE vehicles in their class. For all nine EVs analyzed, the first-owner ownership costs are estimated to be lower for at least one of the three comparable ICE vehicles. In many cases, the EVs matched or exceeded the performance of some of the top-performing ICE vehicles in their class. For all EVs analyzed, the lifetime ownership costs were many thousands of dollars lower than all comparable ICE vehicles' costs, with most EVs offering savings of between \$6,000 and \$10,000. While new EVs were found to offer significant cost savings over comparable ICE vehicles, the cost savings of 5- to 7-year-old used EVs was found to be two or three times larger on a percentage savings basis.

Overall, these results show that the latest generation of mainstream EVs typically cost less to own than similar gas-powered vehicles, a new development in the automotive marketplace with serious potential consumer benefits.

Key Terms

Battery electric vehicle (BEV): A vehicle that operates only on electric power.

Depreciation: The portion of the initial value of an asset (such as a vehicle) that has been lost after a given amount of time. Depreciation is the inverse of the *residual value*.

Discount rate: An interest rate used for discounting future income and expenditures relative to the present value.

Electric vehicle (EV): A vehicle capable of operating on electricity only for an extended period of time. Includes battery electric vehicles, plug-in hybrid electric vehicles and fuel cell electric vehicles¹.

Internal combustion engine vehicle (ICE): A conventional vehicle fueled only by gasoline.

Plug-in hybrid electric vehicle (PHEV): A vehicle that can operate on either electricity or gasoline.

Present value (PV): A sum of future income and expenditures discounted to current year using a discount rate to take into account the fact that costs and expenditures further into the future have a lower value in the present.

Residual value: The portion of the original purchase price of a vehicle remaining after a certain number of years. Residual value is the inverse of *depreciation*.

¹ There are currently no high-volume mainstream fuel cell electric vehicles.

Chapter 1—Resale Value: Long-Range Electric Vehicles Expected to Hold Value As Well As Internal Combustion Engine Vehicles**Introduction**

The electric vehicle market is rapidly changing, largely because the cost of batteries has decreased dramatically over the past decade.² One of the most significant changes is extended driving range. The 2011 Nissan Leaf, for example, had a single-charge range of only 73 miles, whereas the 2019 version had three times that range, at 226 miles. As of model year 2020, at least 11 electric vehicles on the market have a range of 200 miles or more. This sharp improvement in range delivers far more utility for many consumers.

This increased utility is likely to be reflected in higher resale values for the current model year of the Leaf and other higher-range EV models. The purposes of this chapter are to test this hypothesis and estimate how the values of these electric vehicles will hold up over time. The analysis relies on data from proprietary algorithms developed by ALG based on real-world vehicle transaction prices adjusted by CR to account for government purchase incentives.

Key Findings

- Current longer-range battery electric vehicles (BEVs) are expected to maintain their value about as well as comparable internal combustion engine (ICE) vehicles, on average, over the next five years.
- Plug-in hybrid electric vehicles (PHEVs) are expected to hold their value about as well as conventional hybrids of the same vehicle class, on average, over the same period.

Approach

ALG, a data and analytics subsidiary of automotive pricing and information website TrueCar provided CR with projected residual values of all model year 2019 vehicles after five years of ownership as a percentage of the average original price for each model. These projections were made using proprietary algorithms and data from millions of real-world new and used vehicle transactions.

These residual value estimates were then adjusted to take into account the effect of purchase incentives available at the state and federal level on the original price of battery electric and plug-in electric vehicles. This was necessary because the net price after incentives represents

² <https://www.bloomberg.com/news/articles/2020-03-17/an-economic-crash-will-slow-down-the-electric-vehicle-revolution-but-not-for-long>

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

the true price paid by consumers for these vehicles, and it is expected that both the new- and used-car markets will reflect the availability of these incentives.

ALG provided estimates of residual values based on the month of purchase, and the data were updated every two months throughout the year, resulting in six data points per year. Because incentives were phased out for some automakers—General Motors and Tesla, for example—at different points throughout the year, the incentives were applied only for the months in which they were offered, and the resulting residual values were averaged across the six data points for each vehicle for the year.

The value of the federal tax credit for each vehicle model was taken from [fueleconomy.gov](https://www.fueleconomy.gov/feg/taxevb.shtml).³ For state incentives, a weighted average incentive for all BEVs was derived by multiplying the percentage of EV sales in 2019 in a given state⁴ by the value of the state purchase incentive for BEVs.⁵ Ten states provided purchase incentives for BEVs in 2019, and those states accounted for 65 percent of national EV sales. From this, it was calculated that, on average, BEV vehicles sold in 2019 each received \$1,400 in state purchase incentives. Because vehicles are often sold across state lines, we used this weighted average to approximate the effect of state incentives on the overall market. State tax credits were not calculated for PHEVs because of the complexity of how different state incentives apply to different specific PHEV models based on battery size.

Detailed Results

Electric vehicles were grouped into different segments, based on range and price, for analysis. Vehicles were segmented by whether they were classified as luxury or mainstream by TrueCar, and the mainstream EVs were divided by range: greater than 200 miles, between 100 and 200 miles, and under 100 miles. All luxury BEVs had a range of over 200 miles.

Table 1.1 shows a summary of the predicted five-year residual values for each category, with different levels of adjustment (adjusted for federal tax credit, and adjusted for both federal and state tax credits). These values are then compared with the predicted average residual values for comparable conventional internal combustion engine (ICE) vehicle segments. The residual values in the table represent the portion of the effective initial purchase price that is retained after five years of ownership, which is the inverse of depreciation. For example, a residual value of 0.45 indicates that the vehicle has depreciated by 55 percent.

³ <https://www.fueleconomy.gov/feg/taxevb.shtml>.

⁴ <https://www.atlasevhub.com/materials/state-ev-sales-and-model-availability>.

⁵ <https://afdc.energy.gov/laws/state>.

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The data show that with the exception of mainstream BEVs with less than 100 miles of range, all EV categories are expected to hold their value approximately as well as comparable internal combustion engine vehicles.

It should be noted that every vehicle in the under-100-mile category is a low-volume car with sales of less than 1,000 units in 2019⁶ and available only in states with zero-emissions vehicle mandates. This indicates that these vehicles were likely sold largely for compliance reasons, not as mass-market vehicles that were compelling to a broad cross-section of consumers.

Table 1.1. Average Predicted 5-Year Residual Values for EVs Compared with ICE Vehicles

EV/PHEV Category	Adjusted for Federal Tax Credit	Adjusted for Federal and State Tax Credits	Comparable ICE	ICE Segment Comparison
Luxury EV (n=6)	0.47	0.48	0.46	Luxury car, luxury SUV, luxury performance
Mainstream 200-plus-mile range (n=4)	0.44	0.46	0.45	Compact car
Mainstream 100- to 200-mile range (n=4)	0.43	0.45	0.45	Compact car
Mainstream <100-mile range (n=3)	0.28	0.29	0.36	Subcompact car
PHEV (n=12)	0.47		0.48	Hybrid
Luxury PHEV (n=10)	0.43		0.45	Luxury hybrid

⁶ <https://insideevs.com/news/343998/monthly-plug-in-ev-sales-scorecard>.

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The predicted residual data adjusted for federal tax credits are also shown as a scatter plot of all vehicles in each category in Figure 1.1. ICE values are shown for comparison as the average (represented by ♦), +/- one standard deviation (+ and - symbols), and +/- two standard deviations (*) by combining the compact car, midsize car, and compact-utility categories. This illustrates that, like ICE vehicles, not all EVs are expected to hold their value the same, and that other vehicle- and manufacturer-specific factors, such as style, features, reliability, and manufacturer reputation, still affect the relative depreciation of different vehicles.

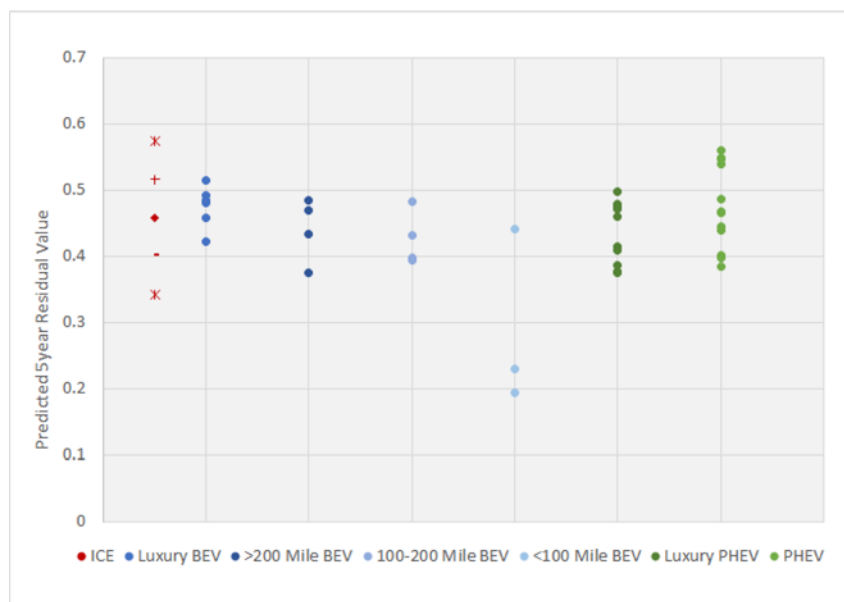


Figure 1.1. Scatter Plot of Predicted 5-Year Residual Values for EVs by Type and Range Adjusted for Federal Tax Credit

Chapter 2—Maintenance: EVs Cost Half as Much to Maintain**Introduction**

Electric vehicles (EVs) are generally expected to cost less to maintain because their electric motors and other drivetrain components have fewer moving parts than internal combustion engines, and they don't require fluid changes.⁷ However, because EVs are relatively new, little hard data are available to put numbers to these claims, and most estimates in the literature are based on predicted repair and maintenance costs.⁸ However, each year CR surveys hundreds of thousands of our members about the reliability and maintenance costs of their vehicles. In recent years this survey sample has included more and more electric vehicles, including thousands of both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). This data was analyzed to estimate average real-world repair and maintenance costs for BEVs, PHEVs, and internal combustion engine (ICE) vehicles.

Key Findings

- Analysis of real-world maintenance and repair cost data from thousands of CR members shows that BEV and PHEV owners are paying half as much as ICE owners are paying to repair and maintain their vehicles.

Approach

Data for this analysis came from Consumer Reports' 2019 and 2020 spring reliability surveys.⁹ This comprehensive survey is sent to hundreds of thousands of CR members and is used as the basis for CR's reliability ratings. Among many other questions, individual drivers are asked to estimate how much they spent on repairing and maintaining their vehicle over the past 12 months, as well as how many miles they drove in the past 12 months, and how many total miles their vehicle has on it.

The data were filtered to remove:

- Incomplete responses.
- Vehicles that reported traveling less than 2,000 miles in the past 12 months.
- Vehicles that reported traveling more than 60,000 miles in the past 12 months.
- Vehicles that reported maintenance costs of over \$20,000 over the past 12 months.
- Vehicles with more than 200,000 total miles.

⁷ <https://www.consumerreports.org/hybrids-evs/your-ev-questions-answered-electric-vehicle-faq/#reliable>

⁸ https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf

⁹ <https://www.consumerreports.org/car-reliability-owner-satisfaction/consumer-reports-car-reliability-faq/>

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These filters on the data were used to eliminate outliers and keep the sample within the range of reasonably likely consumer experience while retaining as much of the original data set as possible. While 60,000 miles is a lot of driving for one year, it's within the range of possibilities for, for example, a salesman with a large territory, or someone who drives full-time for a ride-hailing company, such as Uber or Lyft. Similarly \$20,000 is a lot to spend on vehicle repairs but may represent the cost of major repairs on a luxury vehicle.

The final data set was then sorted by total vehicle mileage. Average maintenance costs were estimated in three mileage bins: 0 to 50,000 miles, 50,000 to 100,000 miles, and 100,000 to 200,000 miles. For each bin, a vehicle-miles-traveled (VMT) weighted average repair and maintenance cost per mile was calculated. To account for any bias in the data based on the brands of vehicles purchased by CR members, for ICE vehicles the estimates were reweighted based on calculated average maintenance costs for each automaker and the average market share over the past five years for each brand, using data from auto industry analyst Wards Intelligence.¹⁰ The sample size for PHEVs and BEVs was not large enough to do a similar automaker weighted average calculation, but for ICE vehicles the difference between the automaker weighting and the total average sample for each mileage bin was negligible.

Detailed Findings

The results of the analysis are shown in Table 2.1, binned by mileage range and averaged over a 200,000-mile vehicle lifetime. Notable results are that estimated lifetime average repair and maintenance costs for BEVs and PHEVs are approximately half the cost for ICE vehicles. This is generally consistent with other sources that have estimated the relative repair and maintenance costs of EVs at 40 percent¹¹ and 47 percent.¹²

The data show that repair and maintenance costs are slightly higher for PHEVs than for BEVs until the 100,000-mile mark, and slightly lower beyond 100,000 miles. It should be noted, however, that there is a higher degree of uncertainty in these numbers because of a lower sample size: A little over 200 PHEV vehicles with more than 100,000 miles, and only 55 BEVs. Furthermore, the 55 BEVs with more than 100,000 miles were predominantly early versions of the Nissan Leaf and Tesla Model S, suggesting that our projections may overestimate the long-term maintenance costs expected from current-generation BEVs as automakers learn from their early models. These estimates will continue to be refined over the next few years as more data

¹⁰ Wards Intelligence, U.S. Vehicle Sales by Company, 2015-2019 data series.

<https://wardsintelligence.informa.com/WM060875/US-Vehicle-Sales-by-Company-20152019>.

¹¹ <https://neo.ubs.com/shared/d1ZTxnvF2k>.

¹² https://www.2degreesinstitute.org/reports/comparing_fuel_and_maintenance_costs_of_electric_and_gas_powered_vehicles_in_canada.pdf.

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on more electric vehicles at higher mileages become available in Consumer Reports' survey sample.

Table 2.1. Estimated Per-Mile Repair and Maintenance Costs by Powertrain

Powertrain Type	0-50K Miles	50K-100K Miles	100K-200K Miles	Lifetime Average
BEV	\$0.012	\$0.028	\$0.043 ¹³	\$0.031
PHEV	\$0.021	\$0.031	\$0.033 ⁵	\$0.030
ICE	\$0.028	\$0.060	\$0.079	\$0.061

The results are put into the context of consumer budgets in Table 2.2, which shows the lifetime repair and maintenance costs for vehicles of the different powertrain types. They show that BEVs and PHEVs will both cost consumers about \$4,600 less to repair and maintain over their lifetimes, compared with ICE models when discounted to the present value.

Table 2.2. Lifetime Maintenance Costs by Powertrain¹⁴

Powertrain Type	Lifetime Maintenance and Repair Cost	Lifetime Savings vs. ICE
ICE	\$9,200	
BEV	\$4,600	\$4,600
PHEV	\$4,600	\$4,600

¹³ Lower confidence in this value because of the small sample size.

¹⁴ Present value at 3 percent discount rate in 2019 dollars over a 200,000-mile lifetime.

Chapter 3—Fuel Costs: No More Trips to the Gas Station**Introduction**

Home charging has the potential to provide several benefits for consumers, one of which is simply the convenience of not needing to stop at a gas station multiple times per month. Further, charging a BEV at home is much less expensive than paying for gasoline. Longer trips will still require occasional stops at stations equipped with DC fast chargers—or Superchargers, as Tesla calls them¹⁵—which can recharge your battery in 30 to 45 minutes, or about the time it takes to eat a quick meal.¹⁶ This chapter estimates how much of a consumer's typical charging can be done at home vs. on the road at a DC fast-charging station. Then it estimates the total fuel cost savings a consumer can expect for different classes of BEVs compared with internal combustion engine vehicles.

Key Findings

- EV owners will spend 60 percent less to fuel their vehicle.
- While there is variability among states because of differing gasoline and electricity prices, electric vehicle drivers will save on fuel in every state, with consumers in the majority of states saving within 10 percent of the national average savings.
- Owners of BEVs with a range of 250 miles or greater will be able to do 92 percent of their charging at home, requiring only six stops at a DC fast-charging station per year.

Approach

The first step in this analysis was determining what fraction of a consumer's charging could typically be done at home. One commonly used approach is to calculate what's called a utility factor, which is an estimate of the fraction of total miles driven by a typical driver that could be completed by an EV that charges only at home once a day. Using data from over 100,000 consumer trips, researchers at the Argonne National Laboratory developed an equation for a BEV utility factor as a function of that EV's range.¹⁷ The utility factors calculated by ANL are shown in Table 3.1.

¹⁵ <https://www.tesla.com/supercharger>.

¹⁶ <https://www.consumerreports.org/hybrids-evs/electric-car-charging-network-is-expanding>.

¹⁷ Duoba, M., "Developing a Utility Factor for Battery Electric Vehicles," SAE Int. J. Alt. Power. 2(2):362-368, 2013 (<https://doi.org/10.4271/2013-01-1474>).

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These numbers were then adjusted to account for the fact that consumers are unlikely to drive their BEV until its charge is fully depleted. Using a safety factor of 20 percent, we determined the number of trips to a public charging station required for every 15,000 miles of driving.¹⁸

Table 3.1 BEV Utility Factor as a Function of BEV Range

BEV Range	Utility Factor	Percentage of Charging at Home ¹⁹	Estimated DC Fast-Charging Sessions for 15K Miles ²⁰
100	78%	70%	56
150	88%	84%	20
200	92%	89%	11
250	95%	92%	6
300	96%	94%	4

To estimate charging expenses, costs were split between home charging and public DC fast charging (DCFC) based on the figures in Table 3.1.²¹ Home charging costs were taken from the Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2020 baseline scenario.²² State-by-state charging costs were also estimated, but the AEO does not project state-level costs, so average residential electric costs were drawn from the EIA State Energy Data System over the past five years (2014 to 2018) of data that were available.²³ For the cost of DC fast chargers, a value of 40 cents per kilowatt-hour was used, based on data from multiple sources.²⁴ The same methodology and EIA sources were used for both national and state gasoline prices for comparison with ICE fueling costs.

¹⁸ Approximately the average annual distance driven over the first seven years of a vehicle lifetime for an SUV or crossover. Cars tend to be driven slightly fewer miles and pickup trucks slightly more. National Highway Traffic Safety Administration Final Regulatory Impact Analysis, Table VI-212 (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

¹⁹ Assumes a 20 percent safety factor. For example, a 100-mile range is treated as effectively an 80-mile range for the purposes of this calculation.

²⁰ Number of sessions is calculated by dividing the number of miles needing public charging by 80 percent of the range of the vehicle, assuming consumers charge up 80 percent of their total range at each charging stop.

²¹ This analysis assumes that consumers do not opportunistically take advantage of the over 15,000 free Level 2 chargers that are available around the country (<https://www.ucsusa.org/sites/default/files/attach/2017/11/cv-report-ev-savings.pdf>).

²² <https://www.eia.gov/outlooks/aeo>.

²³ <https://www.eia.gov/state/seds/seds-data-complete.php?sid=US#PricesExpenditures>.

²⁴ Union of Concerned Scientists found the majority of DCFCs cost between 36 cents and 48 cents per kilowatt-hour (<https://www.ucsusa.org/sites/default/files/attach/2017/11/cv-report-ev-savings.pdf>). NREL found an average cost of 35 cents/kWh (<https://www.nrel.gov/docs/fy19osti/72326.pdf>).

Tesla DCFC costs 28 cents/kWh (<https://www.tesla.com/support/supercharging>).

Electrek estimate of 41 cents/kWh (<https://electrek.co/2019/08/12/kwh-pricing-ev-drivers-miss-benefits>).

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For comparison, average vehicle efficiency levels were assumed for each of three vehicle classes (car, crossover/SUV,²⁵ and pickup). Efficiency levels for ICE vehicles were taken from the 2020 Environmental Protection Agency trends report for model year 2019 vehicles.²⁶ These efficiencies were then adjusted to increase them to account for the increase in fuel-economy standards between 2019 and 2020.²⁷ For BEVs an average efficiency level was calculated for cars based on the average efficiency of the seven BEV cars available on the market with at least 150 miles of range and costing less than \$100,000.²⁸ Efficiency levels for BEVs in other classes were estimated by assuming the same relative efficiency for BEVs as ICE vehicles between classes.²⁹ The efficiencies used in the analysis are shown in Table 3.2.

Table 3.2. Average Vehicle Efficiencies by Vehicle Class

Class	Electric Efficiency (MPGe ³⁰)	Gasoline Efficiency (mpg)
Car	120	32
Crossover/SUV	97	24
Pickup	76	20

Detailed Findings

For analysis in this chapter, a single standard-range EV was selected for estimation of charging costs. Based on the best-selling EVs on the market, a value of 250 miles was selected for the range. The numbers in Table 3.1 may help explain why many automakers are targeting EVs with a range of around 250 miles per charge. At that range, even with a 20 percent safety factor, a typical consumer could do 92 percent of their driving with home charging and would require an average of only six stops at a fast charger per year. This compares with around 40 stops at gas

²⁵ Utility includes both crossovers and SUVs, given the difficulty in clearly differentiating these two vehicle classes.

²⁶ The utility class is based on a sales weighted average of the "car SUV" and "truck SUV" classes defined by EPA (<https://www.epa.gov/automotive-trends/explore-automotive-trends-data#DetailedData>).

²⁷ Based on the current Corporate Average Fuel Economy (CAFE) and greenhouse gas standards, an estimated improvement of 4 percent improvement in car fuel economy and 1.7 percent improvement in light truck fuel economy was required for model year 2020 as compared with model year 2019. Based on analysis from:

<https://advocacy.consumerreports.org/wp-content/uploads/2019/08/The-Un-SAFE-Rule-How-a-Fuel-Economy-Rollback-Costs-Americans-Billions-in-Fuel-Savings-and-Does-Not-Improve-Safety-2.pdf>.

²⁸ Tesla Model 3, Tesla Model S, Nissan Leaf, Chevrolet Bolt, Hyundai Ioniq, Hyundai Kona, and Kia Niro.

²⁹ This assumption was tested by calculating the ratio of the efficiency of Tesla Model 3 and Model S (car) to the Model Y and Model X (utility), and the results were found to be within a few percentage points of each other for both vehicle classes.

³⁰ Miles-per-gallon equivalent.

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stations every year for the same driving distance in an ICE vehicle. Moving from 250 to 300 miles of range per charge adds 20 percent to the cost, weight, and volume of batteries but reduces the percentage of total annual miles that require public charging by only 2 percent. At ranges below 200 miles per charge, the number of annual charging trips for the typical driver increases much more quickly, potentially indicating why earlier, lower-range EVs were less popular.

The estimated fuel savings a consumer will experience from buying an EV is illustrated in Figures 3.1 to 3.3. Figure 3.1 shows the fuel cost for ICE vehicles compared with BEV vehicles over 15,000 miles, the approximate average annual mileage for owners of new vehicles.³¹ This shows that even factoring in some charging at relatively expensive DC fast chargers, BEVs are expected to cost about 60 percent less to fuel than comparable ICE vehicles, resulting in \$800 to \$1,300 in annual savings, depending on vehicle class.

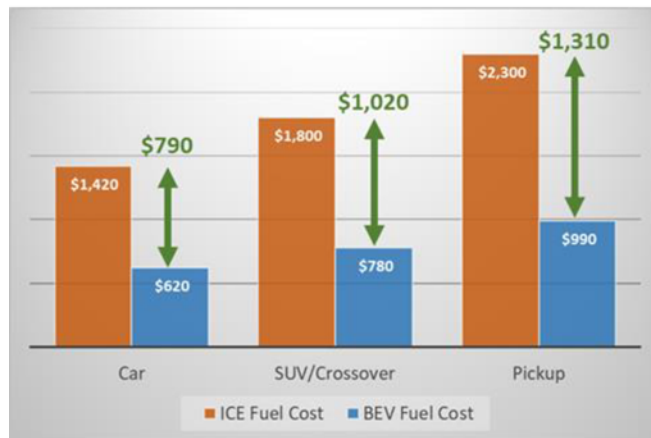


Figure 3.1. Estimated Fuel Cost for 15,000 Miles by Vehicle Class

³¹ Based on recent NHTSA VMT schedules. See Tables VI-212-214 (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

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Figures 3.2 and 3.3 are based on a discounted cash-flow analysis³² of typical vehicles over the first ownership period³³ and vehicle lifetime.³⁴ These values represent the present value (at the time of purchase) of future fuel savings from the vehicle.

A number of sensitivities were run with different gas-price assumptions, which are detailed in Appendix A. Even at fairly low gas prices, BEVs offer very large savings over comparable ICE vehicles in all classes. Using the EIA's low-gas-price scenario, which projects an average gas price of \$2.33 per gallon over the next 10 years, consumers can still expect to save around one-third of their fuel costs. However, the recent history of gas prices and economic activity indicates that dramatic gas-price declines during challenging economic times tend to be relatively short-lived, while most new vehicles last 15 to 20 years.³⁵ Because a return to gas prices closer to what we have experienced over the past decade is likely over the next year or two, as the economy recovers from its current downturn, consumers are likely to save a lot more over the first seven years and lifetime of the vehicle than estimated assuming using today's fuel prices.

Another thing to note is that gasoline and electricity prices can vary significantly from state to state. We analyzed costs by state; the results are summarized in Appendix B. This analysis showed that the fuel savings for EVs for 48 of the 50 states were within 30 percent of the average, with the majority of states falling within 10 percent of the average. The only two states outside of the 30 percent range were Oregon and Washington, where consumers who switch to a BEV can expect to see increased savings of 32 percent and 38 percent, respectively, compared with the national average. The high savings in these states result from a combination of higher-than-average gas prices and lower-than-average electricity prices because of the abundance of cheap hydropower in the Pacific Northwest.

³² Present value at a 3 percent discount rate in 2019 dollars.

³³ Assumed to be seven years, based on data from IHS Markit (https://news.ihsmarket.com/prviewer/release_only/slug/automotive-vehicles-getting-older-average-age-light-cars-and-trucks-us-rises-again-201).

³⁴ VMT schedules in Tables VI-212-214. Survival weighted average lifetime mileage in Table VI-219. Lifetime miles rounded down to 200,000 for all vehicle classes from 210,000 for cars and 230,000 for light trucks (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

³⁵ Antonio Bento, Kevin Roth, Yiyou Zuo, "Vehicle Lifetime Trends and Scrappage Behavior in the U.S. Used Car Market" (Jan. 18, 2016). Available at http://faculty.sites.uci.edu/kevinroth/files/2011/03/Scrappage_18Jan2016.pdf.

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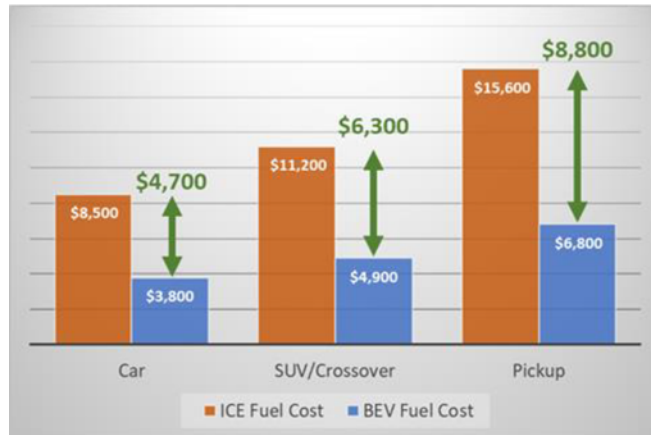


Figure 3.2. Discounted First Owner Fuel Costs for Average BEV and ICE by Vehicle Class³⁶

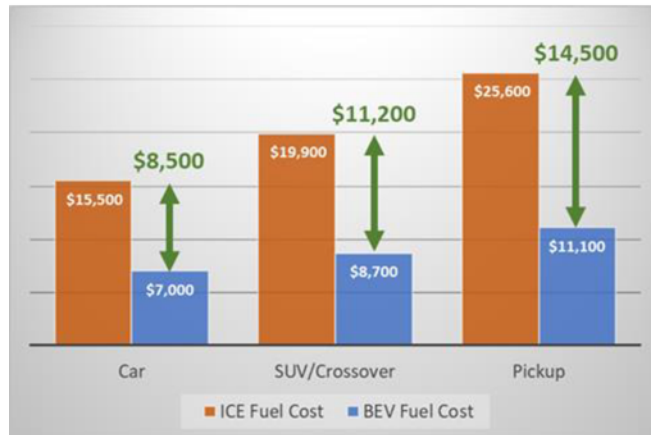


Figure 3.3. Discounted Lifetime Fuel Costs for Average BEV and ICE by Vehicle Class³⁷

³⁶ Present value at 3 percent discount rate 2019 dollars for the first seven years and 200,000-mile, 15-year lifetime.

³⁷ Present value at 3 percent discount rate 2019 dollars for the first seven years and 200,000-mile, 15-year lifetime.

Chapter 4—Current EV Ownership Costs: Adding Up the Savings**Introduction**

This section applies the findings of the previous three chapters to estimate the relative ownership costs of currently available battery electric vehicles, plug-in hybrid electric vehicles, and comparable internal combustion engine vehicles.

While EVs save consumers money through lower fuel and maintenance costs, most EVs on the market today are priced higher than most comparable ICE models in their class, even after accounting for federal purchase incentives. So this chapter compares the most popular EVs (both BEVs and PHEVs) that consumers can buy today with the best-selling, top-rated, and most efficient non-EVs in their class to determine whether, on net, EVs will save consumers money. It also compares high-performing EVs with the least expensive ICE vehicle in their class that achieves the same 0-to-60-mph acceleration performance to understand the value that certain EVs may provide to the subset of consumers who place value on performance.³⁸

Key Findings

- Seven of the nine most popular EVs on the market cost first-time owners less than the best-selling, and top-rated ICE vehicles in their class, in many cases matching or exceeding the performance of some of the top-performing ICE vehicles in their class.
- Lifetime ownership costs for all nine of the most popular EVs on the market under \$50,000 are many thousands of dollars cheaper than the best-selling and top-rated ICE vehicles in their class, with typical savings ranging between \$6,000 and \$10,000.

Approach

This analysis focuses on model year 2020 and 2021 BEVs and PHEVs. It brings together depreciation, financing, fuel, and repair and maintenance costs, and compares them with similar ICE vehicles. It does not include other vehicle ownership costs, such as sales or property taxes, registration fees, and insurance. These costs are also important, but they vary much more by location and driver demographics and history, and are more challenging to generalize. Furthermore, the cost of installing a home Level 2 charger is also not included. Common chargers cost between \$300 and \$700, with an additional \$750 for installation if a 240v outlet is

³⁸ In our 2019 fuel economy survey, only 12 percent of consumers said that performance was one of the top three attributes they wanted to see improved in their current vehicle as compared to 37 percent who wanted better fuel economy and 26 percent who wanted lower maintenance costs.
<https://advocacy.consumerreports.org/wp-content/uploads/2019/08/Consumer-Reports-Fuel-Economy-Survey-Report-2019-1.pdf>.

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not available.³⁹ This is not an insignificant cost, and it will have to be factored into a purchasing decision, but it is a one-time cost that will not have to be repeated for future BEV purchases. Furthermore, many utilities offer rebates to help reduce the cost of installing an EV charger, and there is a 30 percent federal tax credit on the purchase and installation of home EV chargers.⁴⁰ Also, most PHEVs have small enough batteries that they can often be charged directly from a standard wall outlet and don't require a special charger.⁴¹

The EVs included in this analysis were selected based on popularity and price. They fall into a few categories: BEVs and PHEVs that sold at least 10,000 units in 2019,⁴² recently released EV models (Tesla Model Y and Ford Escape PHEV), and models that are expected to arrive in dealerships within two months and can currently be ordered (Ford Mach E and Toyota RAV4 Prime). A price cap of \$50,000 was also applied, which eliminated Tesla's Model X and Model S. This left five BEVs and four PHEVs. These vehicles were then sorted into five vehicle classes: hatchbacks, sedans, crossovers, luxury sedans, and luxury crossovers.

For each category, four comparable ICE vehicles were selected. For each vehicle class, three vehicles were selected: the most efficient ICE vehicle, the best-selling ICE vehicle, and the top-rated by Consumer Reports. Furthermore, all five BEVs and one PHEV had near-class-leading acceleration performance. To account for this, these vehicles were also matched against a fourth vehicle, an ICE vehicle selected as having similar 0-to-60-mph acceleration performance. For all vehicles the lowest trim was selected for comparison, except for the performance category, where specific trims were selected to find the lowest-cost vehicle in the class that matched the EV performance level. A summary of the vehicles selected for analysis is shown in Table 4.1. Detailed characteristics of the individual vehicles can be found in Appendix C.

³⁹ <https://www.consumerreports.org/hybrids-evs/how-to-choose-the-best-home-wall-charger-for-your-electric-vehicle/>

⁴⁰ <https://www.chargepoint.com/incentives/home>.

⁴¹ <https://www.energy.gov/eere/electricvehicles/charging-home#:~:text=Level%201%20adds%20about%202,even%20some%20all%20Delectric%20vehicles>.

⁴² <https://insideevs.com/news/343998/monthly-plug-in-ev-sales-scorecard>.

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Table 4.1. Summary of Vehicles Selected for Analysis and Comparison

Vehicle Category	Hatchback	Sedan	Crossover	Luxury Sedan	Luxury Crossover
BEV	Chevy Bolt Nissan Leaf		Ford Mach E	Tesla Model 3	Tesla Model Y
PHEV	Toyota Prius Prime	Honda Clarity	Ford Escape PHEV Toyota RAV4 Prime		
Most Efficient	Toyota Prius	Toyota Camry Hybrid	Toyota RAV4 Hybrid	Lexus LS 300h	Lexus NX300h
Best-Selling	Honda Civic Hatchback	Toyota Camry	Toyota RAV4	N/A ⁴³	Lexus RX350
Top-Rated	Hyundai Elantra GT	Subaru Legacy	Mazda CX5	Audi A4	Infiniti QX50
Performance	VW Golf GTI		Mazda CX5 GTR Turbo	BMW 330i	BMW x3 m40i

All ownership costs were calculated as a present value at a discount rate of 3 percent. Costs were calculated separately as capital costs (depreciation and financing) and operating and maintenance (O&M) costs (fuel and repair and maintenance). Ownership costs were calculated for two time periods: the first ownership period and vehicle lifetime. For the first owner an ownership period of seven years was used.⁴⁴ For lifetime costs a total lifetime mileage of 200,000 miles was used.⁴⁵ For all ownership periods the VMT-per-year figure was determined using the National Highway Traffic Safety Administration's recently updated VMT schedules for cars, SUVs, and pickup trucks.⁴⁶

⁴³ The Tesla Model 3 is the best-selling luxury sedan. The BMW 3-series is the best selling ICE vehicle in the class so the 330i is used as both the best-selling and performance comparison for the Model 3.

⁴⁴ https://news.ihsmarkit.com/prviewer/release_only/slug/automotive-vehicles-getting-older-average-age-light-cars-and-trucks-us-rises-again-201.

⁴⁵ NHTSA projects survival weighted average lifetime mileage of 210,000 miles for cars and 230,000 miles for light trucks. See Table VI-219

(https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

⁴⁶ See Tables VI-212-214

(https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

For estimating capital costs the vehicle was assumed to be purchased with a six-year loan.⁴⁷ The interest rate on the loan was 4.7 percent.⁴⁸ The initial purchase price for each vehicle was obtained from CR partner TrueCar. TrueCar provides an estimated market average price, based on recent real-world transaction prices, for any vehicle you select. This accounts for the fact that vehicles rarely sell for their manufacturer's suggested retail price (MSRP). For EVs for which federal tax credits were available, the value of the federal tax credit was subtracted from the vehicle purchase price. Any state tax incentives were not factored into the analysis. For the first owner, the owner was then assumed to recover the residual value of the vehicle at the time of sale. A single depreciation curve was applied uniformly to all vehicles based on the analysis in Chapter 1. The specifics of the depreciation curve are described in Appendix D.

Operating and maintenance costs were calculated based on the approaches laid out in Chapters 2 and 3. Maintenance costs were calculated each year based on the per-mile numbers in Table 2.1. Fuel costs were calculated as described in Chapter 3 for BEVs and ICE vehicles using the EIA's AEO 2020 baseline scenario gasoline and electricity cost projections into the future. Vehicle efficiencies were taken from CR's real-world fuel-economy tests, where available; EPA ratings were used for vehicles not yet tested by CR.⁴⁹

For BEVs the fraction of miles charged at home vs. public fast charging was adjusted for their actual EPA-rated range, and the range was reduced by 10 percent after five years and 20 percent after 10 years to account for battery degradation.⁵⁰ This results in some small increases in average per-mile charging costs for BEVs over time. For PHEVs the average miles driven on electricity vs. gasoline was estimated using the Society of Automotive Engineers' Standard J2841 Multi-Day Individual Utility Factor.⁵¹ It was developed based on real-world driving data from individual consumers and estimates the percentage of miles that individuals are likely to drive on electric vs. gasoline, based on the electric range of their vehicle. All charging for PHEVs is assumed to be home charging because PHEVs can easily run on gasoline for longer trips.

Detailed Findings

Across all ownership periods almost all BEVs and PHEVs showed significant savings over all comparable vehicles. In general, savings were greater relative to the best-selling and Consumer

⁴⁷ The average new-car loan in June 2020 was 70 months (<https://www.edmunds.com/industry/press/auto-loan-interest-rates-see-a-slight-lift-in-june-according-to-edmunds.html>).

⁴⁸ Based on rates for consumers with a credit score between 660 and 720 (<https://www.experian.com/blogs/ask-experian/auto-loan-rates-by-credit-score>).

⁴⁹ Fueleconomy.gov.

⁵⁰ Based on data on battery degradation from real-world values averaging 2 percent per year (<https://storage.googleapis.com/geotab-sandbox/ev-battery-degradation/index.html>).

⁵¹ https://www.sae.org/standards/content/j2841_200903.

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Reports' top-rated vehicles than when compared with the most efficient vehicles. This is expected because most fuel-efficiency technologies for ICE vehicles are known to pay for themselves many times over in increased fuel savings, reducing the ownership costs of these vehicles.⁵² Alternatively, savings really ramp up when buyers seek an ICE vehicle that achieves the same acceleration performance as an EV. This reflects the fact that achieving high performance in an ICE vehicle requires a larger, more expensive engine that is also much less efficient, increasing both the capital and operating costs of the vehicle compared with a more typical vehicle in the class. While most PHEVs are not tuned to perform better than most ICE vehicles in their class, all BEVs had near-class-leading acceleration performance.

A summary of the present-value lifetime savings for all nine EVs compared with the best-selling vehicle in their class is presented in Figure 4.1. It shows that in all cases the EV provides lifetime savings worth thousands of dollars at the time of purchase. This general conclusion also holds for comparisons with the top-rated and most efficient ICE vehicle⁵³ in their class. Detailed cost breakdowns, as well as sensitivity cases, are available for all vehicles in Appendix E.

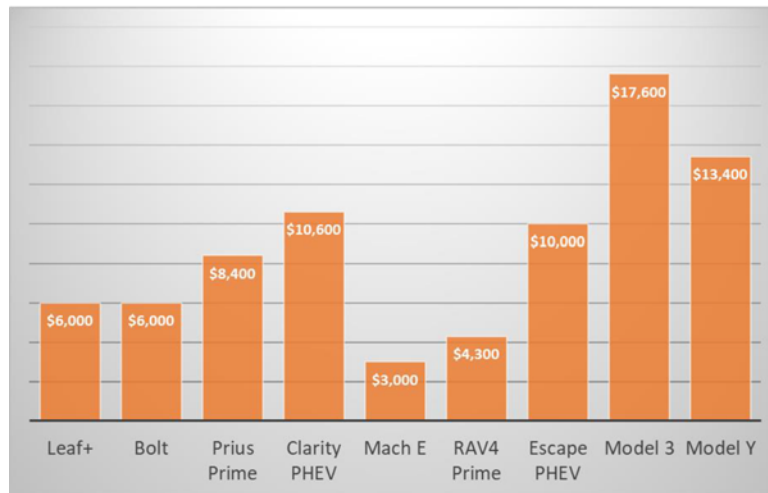


Figure 4.1. Lifetime Savings From EVs vs. Best-Selling ICE Vehicles in Class⁵⁴

⁵² On average, fuel-efficiency technology was found to provide a 3-to-1 return on investment (<https://advocacy.consumerreports.org/wp-content/uploads/2019/08/The-Un-SAFE-Rule-How-a-Fuel-Economy-Rollback-Costs-Americans-Billions-in-Fuel-Savings-and-Does-Not-Improve-Safety-2.pdf>).

⁵³ For the Ford Mach E, it only breaks even with Toyota RAV4 Hybrid, which costs over \$10,000 less and is highly efficient.

⁵⁴ Costs as present value at a 3 percent discount rate in 2019 dollars.

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Detailed results for the first owner in the hatchback and crossover class are shown in Figures 4.2 and 4.3. These figures break out the capital and O&M costs in addition to the totals. They illustrate that while in all these cases the EVs had higher capital costs, the cumulative fuel, repair, and maintenance savings close the ownership cost gap, resulting in overall savings in most comparisons. The two exceptions are the Toyota RAV4 Prime, which only roughly breaks even with the base RAV4 LE and the efficient RAV4 hybrid. However the RAV4 prime is currently selling for an average of more than \$1,300 over MSRP,⁵⁵ likely indicating that demand is outpacing supply, which makes sense because it offers a higher trim level and higher performance at roughly the same net price as the base model. The other vehicle with lower savings is the Ford Mach E, which is available for preorder at around MSRP and expected to hit dealer lots in the coming months.⁵⁶ This vehicle is designed and marketed to be more of a performance/semi-luxury vehicle, and its buyers are more likely to be cross shopping for other higher performance or luxury vehicles than for the base model crossovers it is compared with here.

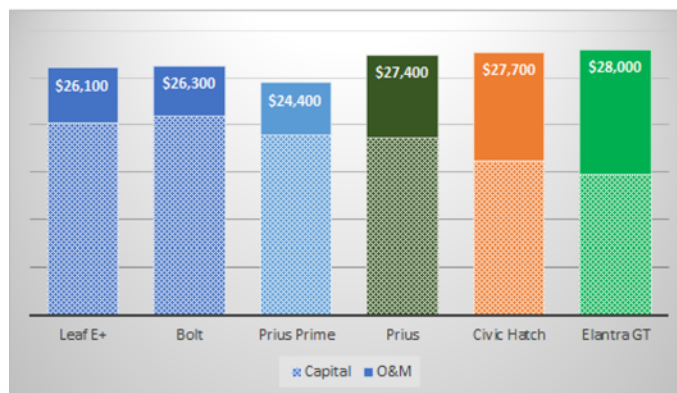


Figure 4.2. First Owner Capital, O&M, and Total Costs for Hatchbacks⁵⁷

⁵⁵ This higher purchase price is included in the analysis, so consumers who can buy the vehicle at MSRP or less will see savings vs. other RAV4 trim levels.

⁵⁶ Rumored preorder numbers range from fewer than 10,000 to more than 40,000 of an estimated 20,000 model year 2021 vehicles expected to be available in the U.S. (<https://electrek.co/2019/11/27/ford-mustang-mach-e-first-edition-sold-out-year-early/#:~:text=All%20we%20know%20is%20that,electric%20car%20revealed%20last%20week,https://www.torquenews.com/9539/2021-ford-mustang-mach-e-order-bank-opens-may-11>).

⁵⁷ Costs as present value at a 3 percent discount rate in 2019 dollars.

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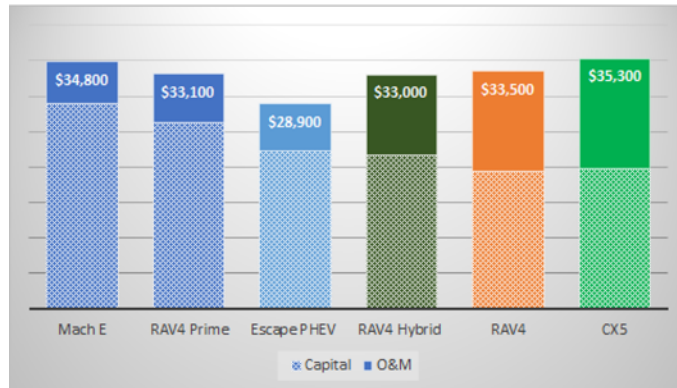


Figure 4.3. First Owner Capital, O&M, and Total Costs for Crossovers⁵⁸

CR surveys have consistently shown that most consumers are satisfied with average performance and that more consumers would prefer increased fuel economy (37 percent of consumers) or lower maintenance costs (26 percent) than would prefer more horsepower (12 percent).⁵⁹

Automakers, however, focus most of their marketing on performance, making it a key theme in almost half of their advertisements.⁶⁰ Given this heavy industry focus on performance, high-performing EVs were compared with ICE vehicles that achieve similar 0-to-60-mph acceleration performance. The results, shown in Figure 4.4, illustrate the first owner and lifetime savings of high-performing EVs relative to ICE vehicles that achieve similar acceleration levels. The results are stark: In most cases new-car buyers who care a lot about performance can get that performance for around \$10,000 less by buying an EV.

⁵⁸ Costs as present value at a 3 percent discount rate in 2019 dollars.

⁵⁹ <https://advocacy.consumerreports.org/wp-content/uploads/2019/08/Consumer-Reports-Fuel-Economy-Survey-Report-2019-1.pdf>.

⁶⁰ <https://advocacy.consumerreports.org/wp-content/uploads/2018/09/auto-ad-content-fact-sheet-9.19.18.pdf>.

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Figure 4.4. First Owner and Lifetime Savings From EVs vs. ICE That Matches Acceleration⁶¹

Overall, these results show that many EVs on the market today can provide consumers the two features they say they most want improved in their next vehicle—lower fuel and maintenance costs—in addition to the feature the auto industry advertises most often —performance—all at a lower overall cost.

⁶¹ Costs as present value at a 3 percent discount rate in 2019 dollars.

Chapter 5—Used EVs: A Pathway Toward More Affordable Transportation**Introduction**

While new cars get most of the attention in the automotive industry, used cars account for most car purchases—70 percent of them in 2019.⁶² This is not surprising because used cars can offer consumers tremendous value: The first owner bears the brunt of the steepest period of depreciation, while new vehicles today are expected to run for an average of over 200,000 miles.⁶³ Hence, used-car buyers capture a large fraction of the lifetime utility of a vehicle while paying a relatively low percentage of the new-car price.

For ICE vehicles this used-car savings is partially offset by higher expected repair and maintenance costs for older vehicles, and the need to continue to pay for fuel, which makes up a large fraction of the total lifetime ownership costs for ICE vehicles. However, as shown in the previous chapters, EVs significantly reduce these costs, while their biggest drawback—higher purchase prices—is partially offset by depreciation. This chapter explores how the savings opportunities of EVs only increase for their subsequent owners, offering a potential pathway toward lowering the cost of transportation for lower-income drivers.

Key Findings

- While new EVs offer significant cost savings over comparable ICE vehicles, the relative cost savings of an EV purchased when it is 5 to 7 years old can be two or three times as large.

Approach

The same ownership cost model described in Chapter 4 was used to estimate the potential savings for used-EV buyers—with a few modifications. Used vehicles were assumed to cost the residual value plus a dealer markup of 15 percent for 3-year-old vehicles and 20 percent for 5-year-old and older vehicles.⁶⁴ The loan and ownership period were also changed to five years

⁶² There were 41 million used-car purchases in 2019, according to Edmunds.com, compared with 17 million new-car sales (<https://www.edmunds.com/industry/press/used-vehicle-market-poised-for-record-sales-in-2019-according-to-new-report-from-edmunds.html>, <https://www.caranddriver.com/news/a30416492/us-auto-sales-2019>).

⁶³ NHTSA projects survival weighted average lifetime mileage of 210,000 miles for cars and 230,000 miles for light trucks, with the average vehicle surviving around 15 years. See Table VI-219 (https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf).

⁶⁴ Based on analysis of the difference between private party and dealer retail value estimates at Edmunds.com for the vehicles in the hatchback class included in table 4.1.

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each to reflect the typically shorter ownership period of used cars.⁶⁵ And the interest rate was increased to 6 percent to reflect higher rates on used cars.⁶⁶ Used vehicles were then analyzed for vehicles that were purchased when they were 3, 5, and 7 years old.

Detailed Findings

Detailed cost breakdowns are shown in Figure 5.1 for the ownership cost of purchasing a 7-year-old hatchback. It shows that operation and maintenance costs make up a much larger percentage of the total ownership costs for used EVs when compared to the new cars analyzed in the previous chapter. This results in even greater total savings for used EVs vs. comparable ICE vehicles.

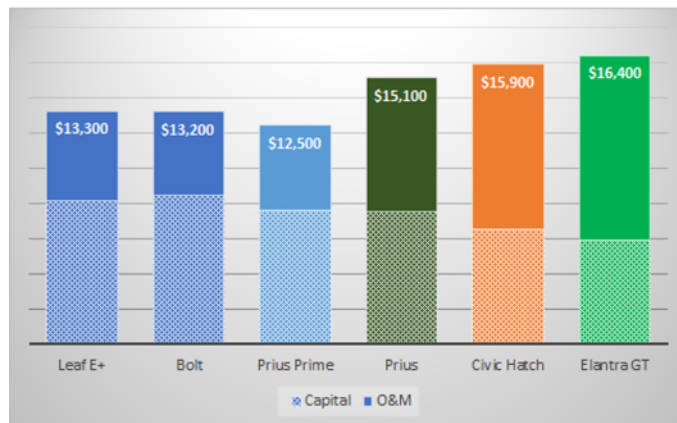


Figure 5.1. 7-Year-Old Used-Vehicle Capital, O&M, and Total Costs for Hatchbacks⁶⁷

This increase in savings is better illustrated in Figure 5.2, which shows the percentage savings for EVs relative to the best-selling vehicle in the class at different purchase times, from new to 7 years old. It shows that while purchasing a new EV saves consumers money, the savings increase significantly as the vehicle's age when purchased increases. The reason is that depreciation reduces the capital cost, increasing the portion of the total cost of ownership from

⁶⁵ Average ownership period of used cars almost 66 months (https://news.ihsmarket.com/prviewer/release_only/slug/automotive-vehicles-getting-older-average-age-light-cars-and-trucks-us-rises-again-201).

⁶⁶ Based on rates for consumers with a credit score between 660 and 720 (<https://www.experian.com/blogs/ask-experian/auto-loan-rates-by-credit-score>).

⁶⁷ Present value in the year of initial vehicle purchase at a 3 percent discount rate in 2019 dollars.

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operation and maintenance, where EVs have a significant advantage. In fact, the relative savings from buying an EV are two to three times as high if the EV is a 5- to 7-year-old used model, compared with purchasing a new EV.

Overall, these results show that used EVs are likely to be a major boon for used-car buyers, especially lower-income buyers. It will take time until these savings are available to a large number of consumers, both for the volume of EV sales in the new-car market to increase and for new EVs to be transferred from their first owners to the secondary market. Unfortunately, both of these factors will delay the realization of these savings to large numbers of potential used-car buyers for a number of years.

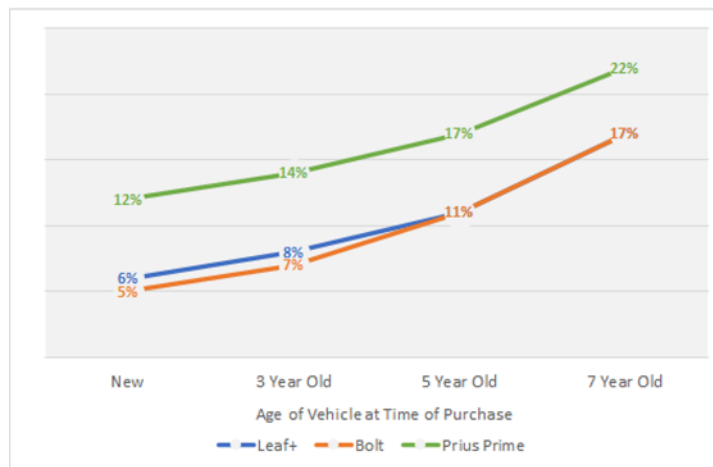


Figure 5.2. EV Percent Savings Compared With Best-Selling ICE by Vehicle Age at Purchase

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Appendix A—Fuel-Cost Sensitivities

Table A.1. Discounted Fuel Savings for an Average BEV Compared With Average ICE, by Class, Assuming National Average Gasoline and Electricity Prices From AEO 2020 Low-Gas-Price Scenario

Class	15,000 miles	First Owner Savings	Lifetime Savings
Car	\$470	\$3,100	\$5,200
Utility	\$610	\$4,200	\$6,900
Pickup	\$790	\$5,900	\$9,100

Table A.2. Discounted Fuel Savings for an Average BEV Compared With Average ICE, by Class, Assuming National Average Electricity Prices From AEO 2020 Baseline and Gas Price From AAA on Aug. 18, 2020⁶⁸

Class	15,000 miles	First Owner Savings	Lifetime Savings
Car	\$400	\$2,600	\$4,300
Utility	\$520	\$3,600	\$5,800
Pickup	\$670	\$5,100	\$7,700

⁶⁸ National average gas price on Aug. 18, 2020, was \$2.18 per gallon (<https://gasprices.aaa.com>).

Appendix B—Fuel Costs by State

Table B.1. Savings from an Average BEV vs. an Average ICE per 15,000 Miles of Driving, by State

State	Car			Crossover/SUV			Pickup			Relative Savings vs. National Average
	Gasoline	Electric	Savings	Gasoline	Electric	Savings	Gasoline	Electric	Savings	
Alabama	\$1,294	\$591	\$703	\$1,648	\$742	\$906	\$2,101	\$940	\$1,161	-12%
Alaska	\$1,863	\$917	\$946	\$2,373	\$1,150	\$1,223	\$3,026	\$1,458	\$1,568	19%
Arizona	\$1,499	\$602	\$896	\$1,909	\$756	\$1,153	\$2,434	\$958	\$1,476	12%
Arkansas	\$1,309	\$510	\$799	\$1,667	\$640	\$1,027	\$2,126	\$811	\$1,315	0%
California	\$1,693	\$804	\$889	\$2,157	\$1,009	\$1,148	\$2,750	\$1,279	\$1,471	12%
Colorado	\$1,388	\$597	\$791	\$1,769	\$749	\$1,020	\$2,255	\$950	\$1,306	-1%
Connecticut	\$1,475	\$914	\$561	\$1,880	\$1,148	\$732	\$2,397	\$1,454	\$942	-28%
Delaware	\$1,439	\$638	\$801	\$1,833	\$800	\$1,032	\$2,337	\$1,014	\$1,323	1%
Dist. of Columbia	\$1,513	\$621	\$892	\$1,927	\$779	\$1,148	\$2,458	\$987	\$1,470	12%
Florida	\$1,337	\$573	\$763	\$1,703	\$720	\$983	\$2,171	\$912	\$1,259	-4%
Georgia	\$1,296	\$577	\$719	\$1,651	\$724	\$927	\$2,105	\$918	\$1,187	-10%
Hawaii	\$1,863	\$1,327	\$537	\$2,374	\$1,665	\$709	\$3,027	\$2,110	\$917	-30%
Idaho	\$1,479	\$514	\$965	\$1,884	\$645	\$1,240	\$2,403	\$817	\$1,586	21%
Illinois	\$1,378	\$612	\$765	\$1,755	\$768	\$987	\$2,238	\$974	\$1,264	-4%
Indiana	\$1,331	\$587	\$744	\$1,696	\$737	\$959	\$2,162	\$933	\$1,229	-6%

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State	Car			Crossover/SUV			Pickup			Relative Savings
	Gasoline	Electric	Savings	Gasoline	Electric	Savings	Gasoline	Electric	Savings	
Iowa	\$1,354	\$587	\$767	\$1,725	\$736	\$988	\$2,199	\$933	\$1,266	-4%
Kansas	\$1,345	\$624	\$720	\$1,713	\$783	\$930	\$2,184	\$993	\$1,191	-9%
Kentucky	\$1,376	\$533	\$843	\$1,753	\$669	\$1,084	\$2,236	\$848	\$1,388	6%
Louisiana	\$1,301	\$497	\$804	\$1,657	\$623	\$1,034	\$2,113	\$790	\$1,323	1%
Maine	\$1,467	\$741	\$725	\$1,868	\$930	\$938	\$2,382	\$1,179	\$1,204	-8%
Maryland	\$1,446	\$860	\$785	\$1,842	\$828	\$1,013	\$2,348	\$1,050	\$1,298	-1%
Massachusetts	\$1,436	\$882	\$555	\$1,830	\$1,106	\$723	\$2,333	\$1,402	\$931	-29%
Michigan	\$1,345	\$706	\$639	\$1,714	\$886	\$828	\$2,185	\$1,123	\$1,062	-19%
Minnesota	\$1,382	\$615	\$767	\$1,761	\$771	\$989	\$2,245	\$978	\$1,267	-3%
Mississippi	\$1,298	\$555	\$742	\$1,654	\$697	\$956	\$2,108	\$883	\$1,225	-7%
Missouri	\$1,314	\$561	\$752	\$1,674	\$705	\$969	\$2,134	\$893	\$1,241	-5%
Montana	\$1,473	\$545	\$927	\$1,876	\$684	\$1,192	\$2,392	\$867	\$1,525	16%
Nebraska	\$1,391	\$542	\$849	\$1,772	\$680	\$1,092	\$2,259	\$862	\$1,397	6%
Nevada	\$1,560	\$599	\$961	\$1,988	\$752	\$1,236	\$2,534	\$952	\$1,582	20%
New Hampshire	\$1,424	\$847	\$577	\$1,814	\$1,062	\$752	\$2,313	\$1,346	\$967	-26%
New Jersey	\$1,393	\$732	\$661	\$1,775	\$919	\$856	\$2,263	\$1,165	\$1,098	-16%
New Mexico	\$1,350	\$610	\$741	\$1,720	\$765	\$955	\$2,194	\$970	\$1,224	-7%
New York	\$1,425	\$842	\$582	\$1,815	\$1,057	\$758	\$2,314	\$1,339	\$975	-26%

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State	Car			Crossover/SUV			Pickup		
	Gasoline	Electric	Savings	Gasoline	Electric	Savings	Gasoline	Electric	Savings
North Carolina	\$1,396	\$557	\$839	\$1,778	\$699	\$1,079	\$2,267	\$886	\$1,382
North Dakota	\$1,437	\$511	\$926	\$1,831	\$642	\$1,189	\$2,335	\$813	\$1,521
Ohio	\$1,389	\$614	\$775	\$1,770	\$771	\$999	\$2,256	\$977	\$1,279
Oklahoma	\$1,317	\$525	\$792	\$1,678	\$659	\$1,019	\$2,139	\$835	\$1,304
Oregon	\$1,600	\$542	\$1,059	\$2,039	\$680	\$1,359	\$2,599	\$861	\$1,738
Pennsylvania	\$1,477	\$660	\$817	\$1,882	\$829	\$1,053	\$2,399	\$1,050	\$1,349
Rhode Island	\$1,463	\$851	\$612	\$1,864	\$1,068	\$795	\$2,376	\$1,354	\$1,022
South Carolina	\$1,314	\$616	\$698	\$1,673	\$773	\$901	\$2,134	\$879	\$1,154
South Dakota	\$1,401	\$564	\$837	\$1,784	\$708	\$1,076	\$2,275	\$897	\$1,378
Tennessee	\$1,336	\$534	\$802	\$1,702	\$670	\$1,032	\$2,170	\$850	\$1,321
Texas	\$1,298	\$566	\$732	\$1,654	\$710	\$944	\$2,109	\$900	\$1,209
Utah	\$1,472	\$545	\$927	\$1,875	\$684	\$1,191	\$2,391	\$867	\$1,524
Vermont	\$1,474	\$803	\$670	\$1,877	\$1,008	\$870	\$2,394	\$1,277	\$1,116
Virginia	\$1,355	\$570	\$786	\$1,727	\$715	\$1,012	\$2,202	\$906	\$1,296
Washington	\$1,594	\$490	\$1,104	\$2,031	\$615	\$1,416	\$2,589	\$779	\$1,810
West Virginia	\$1,463	\$543	\$920	\$1,864	\$682	\$1,182	\$2,377	\$864	\$1,513
Wisconsin	\$1,422	\$670	\$752	\$1,812	\$841	\$971	\$2,310	\$1,065	\$1,244
Wyoming	\$1,379	\$556	\$823	\$1,757	\$697	\$1,059	\$2,240	\$883	\$1,356

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Appendix C—Vehicle Characteristics

Table C.1. Selected Vehicle Characteristics

	Trim	Purchase Price ⁶⁹	Fuel Efficiency (mpg) ⁷⁰	Electric Efficiency (miles/kWh) ⁷¹	Electric Range (miles)	0-60 Acceleration (s) ⁷²
Hatchbacks						
Nissan Leaf E+	S Plus	\$25,398		3.2	226	7.0
Chevy Bolt	LT	\$26,304		3.5	259	6.8
Toyota Prius Prime	LE	\$23,885	54	4	25	10.8
Toyota Prius	LE	\$23,443	52			10.3
Honda Civic Hatchback	LX	\$20,363	34			7.1
Hyundai Elantra GT	Automatic	\$18,555	28			8.7
VW Golf GTI	2.0T S DSG	\$27,879	27			6.6
Sedans						
Honda Clarity PHEV	Base	\$23,345	42	3.3	48	8.3
Toyota Camry Hybrid	LE	\$24,846	47			7.8
Toyota Camry	LE	\$21,690	32			8.0
Subaru Legacy	2.5i	\$21,168	28			8.9

⁶⁹ Based on TrueCar.com market average price for Arlington, VA in August 2020 for specified trim with no options.

⁷⁰ Based on CR test results when available or EPA when not.

⁷¹ Based upon EPA MPGe rating.

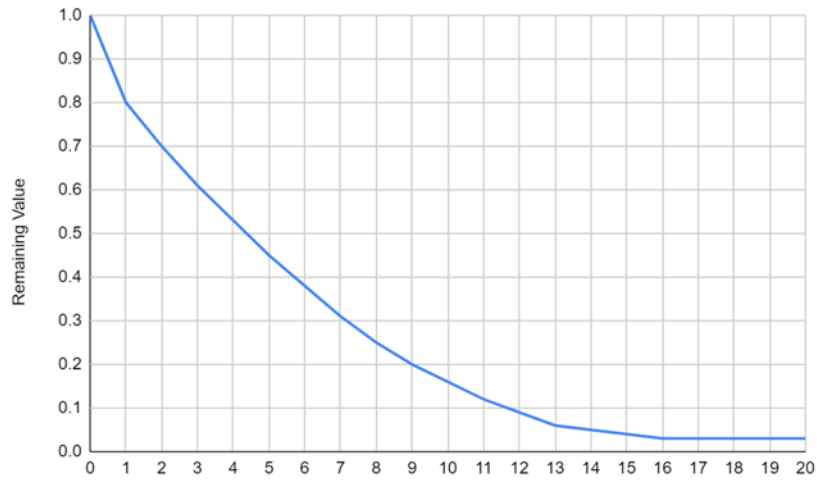
⁷² Numbers from CR tests when available, but based on manufacturer spec or other automotive testing and rating websites. In general 0-60 times are imprecise measures, with CR numbers often a little higher than manufacturer spec when available.

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

	Trim	Purchase Price	Fuel Efficiency (mpg)	Electric Efficiency (miles/kWh)	Electric Range (miles)	0-60 Acceleration (s)
Crossovers						
Ford Mach E	Select	\$36,495		3.4	230	<6
Toyota RAV4 Prime	SE	\$33,105	38	2.8	42	5.7
Ford Escape PHEV	SE	\$28,087	41	3	38	8.7
Toyota RAV4 Hybrid	LE	\$27,301	37			7.8
Toyota RAV4	LE	\$24,369	27			8.3
Mazda CX5	Sport	\$25,021	24			8.6
Mazda CX5 GTR turbo	GTR Turbo	\$34,670	24			6.2
Luxury Sedan						
Tesla Model 3	SR Plus	\$37,990		4.2	250	5.3
Lexus ES 300h	300h	\$41,159	44			8.3
Audi A4	Premium 40 TFSI	\$35,953	27			6.3
BMW 330i ⁷³	330i RWD	\$39,003	28			6.4 ⁷⁴
Luxury Crossovers						
Tesla Model Y	Long Range	\$49,990		3.6	316	4.8
Lexus NX hybrid	300h AWD	\$38,493	29			8.9
Lexus RX	350 FWD	\$42,885	22			7.5
Infiniti QX50	Pure	\$33,918	22			7.2
BMW X3 m40i	xDrive M40i	\$53,105	23			4.8

⁷³ The model 3 is the best selling vehicle in this class, but the BMW 3 series is the best selling ICE vehicle in the class, so it is used for both the performance and best selling category.

⁷⁴ CR test result, although rated at around 5.3 seconds elsewhere.

Appendix D—Depreciation Curve**Figure D.1.** Depreciation Curve

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

Appendix E—Detailed Results of New-Car Ownership Cost Analysis

Table E.1. Detailed Results of New-Car Ownership Cost Analysis for All Vehicles

	Initial Ownership Period			Lifetime		
	Capital	O&M	Total	Capital	O&M	Total
Hatchbacks						
Leaf E+	\$20,100	\$5,900	\$26,100	\$26,400	\$12,500	\$38,900
Bolt	\$20,900	\$5,400	\$26,300	\$27,300	\$11,600	\$38,900
Prius Prime	\$18,900	\$5,500	\$24,400	\$24,800	\$11,700	\$36,500
Prius	\$18,600	\$8,800	\$27,400	\$24,300	\$18,700	\$43,000
Civic Hatchback	\$16,200	\$11,600	\$27,700	\$21,100	\$23,700	\$44,900
Elantra GT	\$14,700	\$13,300	\$28,000	\$19,300	\$26,900	\$46,100
Golf GTI	\$22,100	\$13,600	\$35,800	\$28,900	\$27,500	\$56,500
Sedans						
Clarity PHEV	\$18,500	\$6,500	\$25,000	\$24,200	\$12,300	\$36,500
Camry Hybrid	\$19,700	\$9,400	\$29,100	\$25,800	\$19,700	\$45,500
Camry	\$17,200	\$12,100	\$29,300	\$22,500	\$24,700	\$47,200
Legacy	\$16,800	\$13,300	\$30,100	\$22,000	\$26,900	\$48,800
Crossovers						
Mach E	\$28,900	\$5,900	\$34,800	\$37,900	\$12,100	\$50,000
RAV4 Prime	\$26,300	\$6,900	\$33,100	\$34,400	\$14,300	\$48,600
Escape PHEV	\$22,300	\$6,600	\$28,900	\$29,200	\$13,800	\$42,900
RAV4 Hybrid	\$21,700	\$11,300	\$33,000	\$28,300	\$22,600	\$51,000
RAV4	\$19,300	\$14,100	\$33,500	\$25,300	\$27,600	\$52,900
CX5	\$19,800	\$15,400	\$35,300	\$26,000	\$29,900	\$55,900
CX5 GTR turbo	\$27,500	\$15,400	\$42,900	\$36,000	\$29,900	\$65,900

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

	Initial Ownership Period			Lifetime		
	Capital	O&M	Total	Capital	O&M	Total
Luxury Sedan						
Model 3	\$30,100	\$4,700	\$34,800	\$39,400	\$10,300	\$49,800
ES 300h	\$32,600	\$9,800	\$42,400	\$42,700	\$20,400	\$63,200
A4	\$28,500	\$13,600	\$42,200	\$37,300	\$27,500	\$64,800
330i	\$30,900	\$13,300	\$44,200	\$40,500	\$26,900	\$67,400
Luxury Crossovers						
Model Y	\$39,700	\$5,200	\$44,900	\$51,900	\$11,000	\$62,900
NX hybrid	\$30,500	\$13,400	\$44,000	\$40,000	\$26,400	\$66,300
RX	\$34,000	\$16,500	\$50,500	\$44,500	\$31,800	\$76,300
QX50	\$26,900	\$16,500	\$43,400	\$35,200	\$31,800	\$67,000
X3 m40i	\$42,100	\$16,000	\$58,100	\$55,100	\$30,800	\$86,000

Appendix F—Sensitivity Cases for New-Car Ownership Cost Analysis

This section includes three primary sensitivity cases:

- **Gas Prices**-This sensitivity case relates to the gas price assumptions. Instead of the AEO 2020 baseline, the gas prices are changed to match the AEO 2020 low gas price scenario.
- **Vehicle Ownership Period**-This sensitivity case changes the initial ownership period from 7 years to 5 years. In addition, the loan length is changed from 6 years to 5 years.
- **Discount Rate**-This sensitivity case changes the discount rate from 3% to 7%.

Table F.1. Results of Gas Price Sensitivity, AEO 2020 Low Gas Price

	Initial Ownership Period			Lifetime		
	Capital	O&M	Total	Capital	O&M	Total
Hatchbacks						
Leaf E+	\$20,100	\$5,900	\$26,100	\$26,400	\$12,500	\$38,900
Bolt	\$20,900	\$5,400	\$26,300	\$27,300	\$11,600	\$38,900
Prius Prime	\$18,900	\$5,600	\$24,500	\$24,800	\$10,600	\$35,400
Prius	\$18,600	\$7,700	\$26,300	\$24,300	\$16,400	\$40,800
Civic Hatchback	\$16,200	\$9,800	\$26,000	\$21,100	\$20,300	\$41,400
Elantra GT	\$14,700	\$11,200	\$25,900	\$19,300	\$22,700	\$41,900
Golf GTI	\$22,100	\$11,400	\$33,600	\$28,900	\$23,200	\$52,100
Sedans						
Clarity PHEV	\$18,500	\$6,100	\$24,600	\$24,200	\$11,500	\$35,800
Camry Hybrid	\$19,700	\$8,100	\$27,800	\$25,800	\$17,200	\$43,000
Camry	\$17,200	\$10,200	\$27,400	\$22,500	\$21,000	\$43,500
Legacy	\$16,800	\$11,200	\$28,000	\$22,000	\$22,700	\$44,600

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

	Initial Ownership Period			Lifetime		
	Capital	O&M	Total	Capital	O&M	Total
Crossovers						
Mach E	\$28,900	\$5,900	\$34,800	\$38,900	\$12,100	\$51,000
RAV4 Prime	\$26,300	\$7,500	\$33,800	\$34,400	\$13,700	\$48,100
Escape PHEV	\$22,300	\$7,200	\$29,500	\$29,200	\$13,300	\$42,400
RAV4 Hybrid	\$21,700	\$9,700	\$31,300	\$28,300	\$19,500	\$47,800
RAV4	\$19,300	\$11,900	\$31,200	\$25,300	\$23,300	\$48,600
CX5	\$19,800	\$12,900	\$32,700	\$26,000	\$25,000	\$51,000
CX5 GTR turbo	\$27,500	\$12,900	\$40,400	\$36,000	\$25,000	\$61,000
Luxury Sedan						
Model 3	\$30,100	\$4,700	\$34,800	\$39,400	\$10,300	\$49,800
ES 300h	\$32,600	\$8,400	\$41,100	\$42,700	\$17,700	\$60,500
A4	\$28,500	\$11,400	\$40,000	\$37,300	\$23,200	\$60,500
330i	\$30,900	\$11,200	\$42,100	\$40,500	\$22,700	\$63,100
Luxury Crossovers						
Model Y	\$39,700	\$5,200	\$44,900	\$51,900	\$11,000	\$62,900
NX hybrid	\$30,500	\$11,300	\$41,800	\$40,000	\$22,300	\$62,200
RX	\$34,000	\$13,700	\$47,700	\$44,500	\$26,500	\$71,000
QX50	\$26,900	\$13,700	\$40,600	\$35,200	\$26,500	\$61,700
X3 m40i	\$42,100	\$13,300	\$55,400	\$55,100	\$25,700	\$80,800

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

Table F.2. Results of Ownership Period Sensitivity, 5 year Initial Ownership Period

	Initial Ownership Period		
	Capital	O&M	Total
Hatchbacks			
Leaf E+	\$16,600	\$4,200	\$20,800
Bolt	\$17,200	\$3,900	\$21,000
Prius Prime	\$15,600	\$4,600	\$20,200
Prius	\$15,300	\$6,200	\$21,500
Civic Hatchback	\$13,300	\$8,300	\$21,600
Elantra GT	\$12,100	\$9,600	\$21,700
Golf GTI	\$18,200	\$9,900	\$28,100
Sedans			
Clarity PHEV	\$15,200	\$4,800	\$20,000
Camry Hybrid	\$16,200	\$6,700	\$22,900
Camry	\$14,200	\$8,700	\$22,900
Legacy	\$13,800	\$9,600	\$23,400
Crossovers			
Mach E	\$23,800	\$4,100	\$28,000
RAV4 Prime	\$21,600	\$5,500	\$27,100
Escape PHEV	\$18,300	\$5,300	\$23,600
RAV4 Hybrid	\$17,800	\$8,100	\$25,900
RAV4	\$15,900	\$10,200	\$26,100
CX5	\$16,300	\$11,200	\$27,500
CX5 GTR turbo	\$22,600	\$11,200	\$33,800

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

	Initial Ownership Period		
	Capital	O&M	Total
Luxury Sedan			
Model 3	\$24,800	\$3,200	\$28,000
ES 300h	\$26,900	\$7,000	\$33,800
A4	\$23,500	\$9,900	\$33,400
330i	\$25,500	\$9,600	\$35,100
Luxury Crossovers			
Model Y	\$32,600	\$3,700	\$36,300
NX hybrid	\$25,100	\$9,600	\$34,800
RX	\$28,000	\$12,000	\$39,900
QX50	\$22,100	\$12,000	\$34,100
X3 m40i	\$34,700	\$11,500	\$46,200

Table F.3. Results of Discount Rate Sensitivity, 7% Discount Rate

	Initial Ownership Period			Lifetime		
	Capital	O&M	Total	Capital	O&M	Total
Hatchbacks						
Leaf E+	\$18,600	\$5,100	\$23,700	\$23,200	\$9,400	\$32,600
Bolt	\$19,300	\$4,700	\$24,000	\$24,000	\$8,700	\$32,700
Prius Prime	\$17,500	\$5,500	\$23,000	\$21,800	\$9,000	\$30,800
Prius	\$17,200	\$7,600	\$24,800	\$21,400	\$14,000	\$35,400
Civic Hatchback	\$14,900	\$10,000	\$24,900	\$18,600	\$17,900	\$36,500
Elantra GT	\$13,600	\$11,500	\$25,100	\$16,900	\$20,300	\$37,200
Golf GTI	\$20,400	\$11,800	\$32,200	\$25,500	\$20,800	\$46,200

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

	Initial Ownership Period			Lifetime		
	Capital	O&M	Total	Capital	O&M	Total
Sedans						
Clarity PHEV	\$17,100	\$5,600	\$22,700	\$21,300	\$9,400	\$30,700
Camry Hybrid	\$18,200	\$8,100	\$26,300	\$22,700	\$14,800	\$37,500
Camry	\$15,900	\$10,400	\$26,300	\$19,800	\$18,600	\$38,400
Legacy	\$15,500	\$11,500	\$27,000	\$19,300	\$20,300	\$39,600
Crossovers						
Mach E	\$26,700	\$5,100	\$31,800	\$33,300	\$9,100	\$42,500
RAV4 Prime	\$24,300	\$6,500	\$30,800	\$30,200	\$10,600	\$40,800
Escape PHEV	\$20,600	\$6,300	\$26,800	\$25,700	\$10,200	\$35,900
RAV4 Hybrid	\$20,000	\$9,800	\$29,800	\$24,900	\$17,200	\$42,100
RAV4	\$17,900	\$12,200	\$30,100	\$22,300	\$21,000	\$43,300
CX5	\$18,300	\$13,300	\$31,700	\$22,900	\$22,800	\$45,700
CX5 GTR turbo	\$25,400	\$13,300	\$38,700	\$31,700	\$22,800	\$54,500
Luxury Sedan						
Model 3	\$27,800	\$4,000	\$31,900	\$34,700	\$7,700	\$42,400
ES 300h	\$30,200	\$8,400	\$38,600	\$37,600	\$15,300	\$52,900
A4	\$26,300	\$11,800	\$38,100	\$32,800	\$20,800	\$53,600
330i	\$28,600	\$11,500	\$40,100	\$35,600	\$20,300	\$55,900
Luxury Crossovers						
Model Y	\$36,600	\$4,500	\$41,100	\$45,700	\$8,300	\$54,000
NX hybrid	\$28,200	\$11,600	\$39,800	\$35,200	\$20,100	\$55,200
RX	\$31,400	\$14,300	\$45,700	\$39,200	\$24,300	\$63,500
QX50	\$24,900	\$14,300	\$39,100	\$31,000	\$24,300	\$55,300
X3 m40i	\$38,900	\$13,800	\$52,700	\$48,500	\$23,500	\$72,000

Appendix G—Detailed Results of Used-Car Ownership Cost Analysis

Table G.1. Costs of Used Vehicles Over Five Year Ownership Period

	3-year-old used vehicle			5-year-old used vehicle			7-year-old used vehicle		
	Capital	O&M	Total	Capital	O&M	Total	Capital	O&M	Total
Hatchbacks									
Leaf E+	\$13,600	\$4,700	\$18,300	\$11,200	\$5,000	\$16,200	\$8,100	\$5,100	\$13,300
Bolt	\$14,100	\$4,300	\$18,400	\$11,600	\$4,700	\$16,300	\$8,400	\$4,800	\$13,200
Prius Prime	\$12,800	\$4,400	\$17,200	\$10,500	\$4,700	\$15,200	\$7,600	\$4,800	\$12,500
Prius	\$12,600	\$7,100	\$19,600	\$10,300	\$7,500	\$17,800	\$7,500	\$7,600	\$15,100
Civic Hatchback	\$10,900	\$9,000	\$19,900	\$9,000	\$9,300	\$18,300	\$6,500	\$9,400	\$15,900
Elantra GT	\$9,900	\$10,100	\$20,100	\$8,200	\$10,500	\$18,600	\$5,900	\$10,500	\$16,400
Golf GTI	\$14,900	\$10,400	\$25,300	\$12,300	\$10,700	\$23,000	\$8,900	\$10,700	\$19,600
Sedans									
Clarity PHEV	\$12,500	\$4,800	\$17,300	\$10,300	\$4,700	\$15,000	\$7,500	\$4,500	\$12,000
Camry Hybrid	\$13,300	\$7,400	\$20,800	\$10,900	\$7,900	\$18,800	\$7,900	\$8,000	\$15,900
Camry	\$11,600	\$9,300	\$20,900	\$9,500	\$9,700	\$19,200	\$6,900	\$9,700	\$16,600
Legacy	\$11,300	\$10,100	\$21,500	\$9,300	\$10,500	\$19,800	\$6,800	\$10,500	\$17,200

Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers

	3-year-old used vehicle			5-year-old used vehicle			7-year-old used vehicle		
	Capital	O&M	Total	Capital	O&M	Total	Capital	O&M	Total
	Crossovers								
Mach E	\$19,600	\$4,800	\$24,300	\$16,000	\$5,100	\$21,200	\$11,700	\$5,300	\$16,900
RAV4 Prime	\$17,700	\$5,600	\$23,300	\$14,600	\$5,500	\$20,100	\$10,600	\$5,300	\$15,900
Escape PHEV	\$15,100	\$5,400	\$20,400	\$12,400	\$5,300	\$17,700	\$9,000	\$5,100	\$14,100
RAV4 Hybrid	\$14,600	\$9,000	\$23,600	\$12,000	\$9,500	\$21,500	\$8,700	\$9,500	\$18,300
RAV4	\$13,100	\$10,900	\$24,000	\$10,700	\$11,300	\$22,100	\$7,800	\$11,400	\$19,200
CX5	\$13,400	\$11,800	\$25,200	\$11,000	\$12,200	\$23,200	\$8,000	\$12,200	\$20,200
CX5 GTR turbo	\$18,600	\$11,800	\$30,400	\$15,200	\$12,200	\$27,500	\$11,100	\$12,200	\$23,300
	Luxury Sedan								
Model 3	\$20,400	\$3,900	\$24,200	\$16,700	\$4,300	\$21,000	\$12,200	\$4,400	\$16,600
ES 300h	\$22,100	\$7,700	\$29,800	\$18,100	\$8,200	\$26,300	\$13,200	\$8,200	\$21,400
A4	\$19,300	\$10,400	\$29,600	\$15,800	\$10,700	\$26,500	\$11,500	\$10,700	\$22,200
330i	\$20,900	\$10,100	\$31,000	\$17,200	\$10,500	\$27,600	\$12,500	\$10,500	\$22,900
	Luxury Crossovers								
Model Y	\$26,800	\$4,300	\$31,100	\$22,000	\$4,800	\$26,800	\$16,000	\$4,900	\$20,900
NX hybrid	\$20,600	\$10,400	\$31,100	\$16,900	\$10,900	\$27,800	\$12,300	\$10,900	\$23,200
RX	\$23,000	\$12,600	\$35,600	\$18,900	\$12,900	\$31,800	\$13,700	\$12,900	\$26,600
QX50	\$18,200	\$12,600	\$30,800	\$14,900	\$12,900	\$27,800	\$10,800	\$12,900	\$23,700
X3 m40i	\$28,500	\$12,200	\$40,700	\$23,400	\$12,600	\$35,900	\$17,000	\$12,500	\$29,500

According to Consumer Reports' largest-ever nationally representative survey,¹ 71% of Americans express interest in buying or leasing an electric-only vehicle. Consumer Reports found that more than one third of American adults would "definitely" or "seriously" consider buying or leasing an electric-only vehicle if they were to buy a vehicle today.

WHAT TYPES OF ELECTRIC VEHICLES (EVs) ARE AVAILABLE?

- EV refers to electric-only vehicles.
- EVs can also be referred to as battery electric vehicles (BEVs). BEVs are fully electric vehicles and get all of their power from motors that use batteries charged with electricity. BEVs produce no tailpipe emissions.
- HEVs are hybrid electric vehicles. An HEV runs on both a gasoline engine and an electric motor powered by a battery. The battery in an HEV is charged through regenerative braking. HEVs cannot be plugged in.
- PHEVs are plug-in hybrid electric vehicles. Like HEVs, PHEVs have both a gasoline engine and an electric motor powered by a battery. In PHEVs, the battery is charged by plugging into a power outlet rather than regenerative braking. Once the battery is depleted, PHEVs switch to gasoline power.
- FCEVs are fuel cell electric vehicles that run on compressed hydrogen. They have zero tailpipe emissions because they only emit water vapor. FCEVs have a tank where pure hydrogen gas is stored. The hydrogen gas is converted to electricity which is then used to power the vehicle.

HOW FAR CAN I DRIVE ON A SINGLE CHARGE?

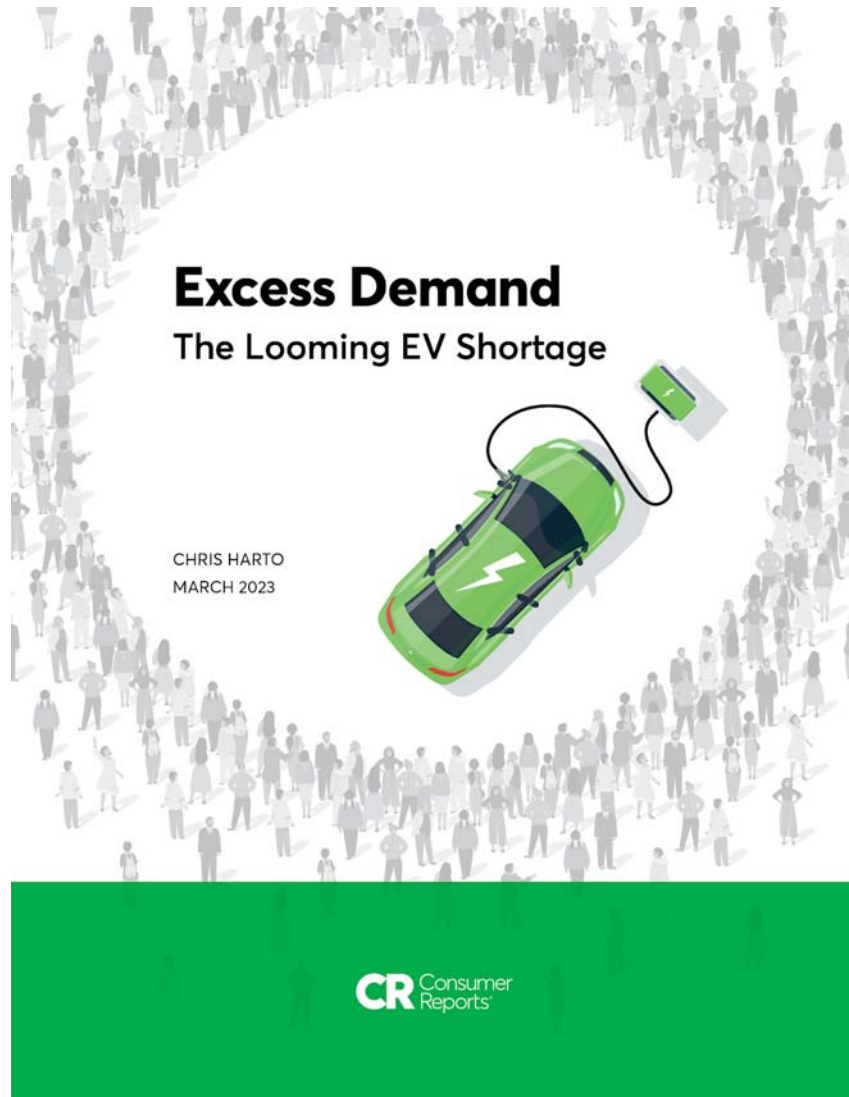
EV range is commonly ~ 250 miles, which is far more than the 35 miles most people typically drive each day.² Overnight charging at home with a regular 120V outlet can satisfy most drivers' needs. The most advanced models can drive about 400 miles between charges. Consumer Reports found that experienced EV owners consider range to be much less of an issue than non-owners — 27% versus 56%.³

WHERE DO I CHARGE MY EV?

EV chargers are classified into three categories:

- Level 1 (120V): All EVs can be charged via standard 120V wall outlet — a great option for overnight home charging. A 120V charger will typically add between 30-60 miles of range overnight, enough for many Americans' daily driving needs.
- Level 2 (240V): Includes most public charging stations, or a good 240V wall-mounted home charging unit. This option can deliver a full charge for a 300-mile range battery in about 6-8 hours. Many states have rebates for home installation.
- Level 3 (direct current or DC fast charging, 480V-1000V): These quick chargers can add 200 miles of range in 20-45 minutes, depending on the vehicle. You will only find Level 3 chargers in public charging stations.

There are more than 51,000 public EV charging locations⁴ in the U.S., but low- and moderate-income communities need greater access.



Executive Summary

Consumer Reports (CR) surveys have shown a 350% increase in consumer demand for battery electric vehicles (BEVs) between 2020 and 2022. While automakers are ramping up supply, the fact that the vehicle fleet turns over very slowly means that most consumers will have to wait a decade or more for an opportunity to own a BEV.

For consumers who said in our 2022 survey that they would “definitely buy or lease” a BEV if they were to get a vehicle today, demand is unlikely to be met until at least the end of the decade on the current supply trajectory—and a virtuous cycle is shaping up that appears poised to rapidly increase consumer demand even further in coming years. This rising tide of demand is projected to be met by lagging supply, leaving many consumers who want a BEV to choose between settling for a gasoline vehicle they don't want, joining an ever-expanding waitlist, or just waiting it out and holding onto their existing vehicle for longer.

Automakers that are too slow to move may find themselves struggling to find buyers for all of the conventional gasoline vehicles they currently plan to build as they simultaneously attempt to catch up with accelerating BEV demand. Failure to respond quickly enough to rapid shifts in consumer preferences will pose significant risks to legacy automakers, and the risk of being too late may prove much greater than the risk of being too early. Regulators have an opportunity with the establishment of new emissions and efficiency standards to ensure that the industry stays on a trajectory that doesn't leave consumers waiting.

Rapidly Growing Consumer Demand For Battery-Electric Vehicles

More and more consumers are coming around to the compelling value proposition offered by many battery-electric vehicles (BEVs) on the market today. They are fun to drive, have smooth and quiet power delivery, and have lower fuel and maintenance costs. They can even be cheaper to own in many cases, even when they cost more to buy up front.¹

In a 2022 survey, CR asked U.S. consumers how likely they were to get an electric-only vehicle if they were purchasing or leasing a vehicle today.² In response, 71% of American adults said they had at least some interest in owning one. Of that group, 14% said they would “definitely buy or lease” a BEV if they were to buy a vehicle today.³ Another 22% said they would “seriously consider” it, and another 35% said they might consider a BEV in the future but aren’t ready to buy one today. (Figure 1 shows the full breakdown of responses.)

“ There are now approximately 45 EV-ready buyers for every EV being manufactured. ”

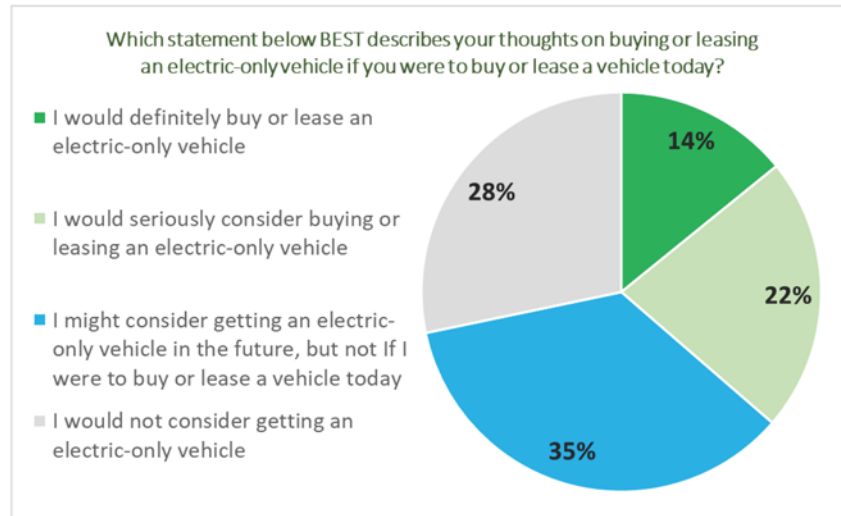
¹ Consumer Reports, “Electric Vehicle Ownership Costs: Today’s Electric Vehicles Offer Big Savings for Consumers” October 2020

<https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf>

² An electric-only vehicle is a vehicle that can only be fueled by electricity, otherwise known as a battery electric vehicle or BEV. This is in contrast to a plug-in hybrid vehicle or PHEV, which can be fueled by either electricity or gasoline.

³ Nationally representative CR survey of 8,027 US adults conducted in January and February 2022. Consumer Reports, “Battery Electric Vehicles & Low Carbon Fuels Survey”, April 2022. Available at: https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July/2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf

Figure 1. Likelihood of Buying or Leasing an Electric-Only Vehicle Today



Some additional context is helpful to fully appreciate what these numbers mean for the U.S. auto market. The 14% of adult Americans who said they would “definitely buy” an electric-only vehicle in our 2022 survey represents approximately 36 million “EV-ready” buyers.⁴ That’s an increase of some 28 million, or 350%, since 2020.⁵

Meanwhile, despite a 230% increase, from 240,000 in 2020, the annual supply of BEVs in 2022 was only 800,000 per year.⁶ The end result is that BEV supply is significantly further behind demand than it was two years ago. There are now approximately 45 EV-ready buyers for every EV being manufactured.

This explains why waitlists for the hottest EVs are being measured in years. A 2022 analysis by Seattle-based startup Recurrent found that an estimated 1.9 million Americans have paid a

⁴ Calculated by multiplying 14% by the US adult population 258 million according to: <https://www.census.gov/library/stories/2021/08/united-states-adult-population-grew-faster-than-nations-total-population-from-2010-to-2020.html>.

⁵ Based on 4% of Americans with drivers licenses who said they would “definitely buy” an electric vehicle in a Nationally representative CR survey of 3,392 US adults with valid driver’s licenses in July and August 2020.

Consumer Reports, “Consumer Interest and Knowledge of Electric Vehicles: 2020 Survey Results,” December 2020. Available at: <https://advocacy.consumerreports.org/wp-content/uploads/2020/12/CR-National-EV-Survey-December-2020-2.pdf>

⁶ Consumer Reports analysis of Wards Intelligence annual sales data, available with subscription at: <https://wardsintelligence.informa.com/datacenter>

deposit to reserve one of eleven popular EVs.⁷ Even more customers are waiting to purchase one of the many other models that don't have formal waitlists, but do have order backlogs.

The Current BEV Supply Trajectory Will Leave Consumers Waiting

The current BEV supply trajectory does not improve the outlook for consumers hoping to get their hands on a battery-electric vehicle. Not only are new BEV sales failing to keep up with consumer demand, the slow turnover of the vehicle fleet means that even when supply catches up, it will take a long time to clear the backlog of demand.⁸

To explore this dynamic, two different BEV supply trajectories were input into a simplified fleet turnover model to estimate the rate of BEV penetration into the light duty vehicle stock.

The first scenario, referred to as the "GM-Scenario" is based loosely on the BEV sales plans of General Motors, which currently has one of the most aggressive long-term BEV expansion plans among major automakers. That supply scenario assumes 50% BEV sales in 2030, which is at the top of GM's stated 2030 sales target range, and 100% BEV sales in 2035.⁹ Figure 2 shows how this supply trajectory would impact the percentage of BEVs in the entire U.S. light-duty vehicle fleet over time.

⁷ Based on an analysis of public information about EV registrations and pre-orders by Recurant. Recurant, "Everything to Know About EV Reservations & Pre-orders," June 11, 2022. Available at: <https://www.recurrentauto.com/research/ev-reservations-pre-orders>

⁸ David Keith, et. al. (2019). *Vehicle Fleet Turnover and the Future of Fuel Economy*, Environmental Research Letters, 14, 021001. Available at: <https://iopscience.iop.org/article/10.1088/1748-9326/aaf4d2#erlaaf4d2s1>

⁹ The "GM-Scenario" assumes 17% BEV sales in 2026 based upon the percentage of EVs estimated by EPA to be needed to comply with greenhouse standards for model year 2026. Supply then grows to 50% in 2030 to match the top of GM's planned production range for this year. Finally BEV supply continues to grow to 100% of new vehicle sales in 2035, GM's target for that year. The full new vehicle sales trajectory for this scenario can be seen in Figure 3.

EPA, "EPA Finalizes Greenhouse Gas Standards for Passenger Vehicles, Paving Way for a Zero-Emissions Future," December 20, 2021. Available at: <https://www.epa.gov/newsreleases/epa-finalizes-greenhouse-gas-standards-passenger-vehicles-paving-way-zero-emissions>

General Motors, "Ford, GM and Stellantis Joint Statement on Electric Vehicle Annual Sales," Available at: <https://news.gm.com/newsroom.detail.html/Pages/news/us/en/2021/aug/0805-electric.html>

General Motors, "General Motors, the Largest U.S. Automaker, Plans to be Carbon Neutral by 2040," Available at: <https://news.gm.com/newsroom.detail.html/Pages/news/us/en/2021/jan/0128-carbon.html>

**Figure 2. Modeled BEV Penetration into the US Vehicle Fleet Through 2050
Assuming the GM-Scenario for BEV Sales¹⁰**

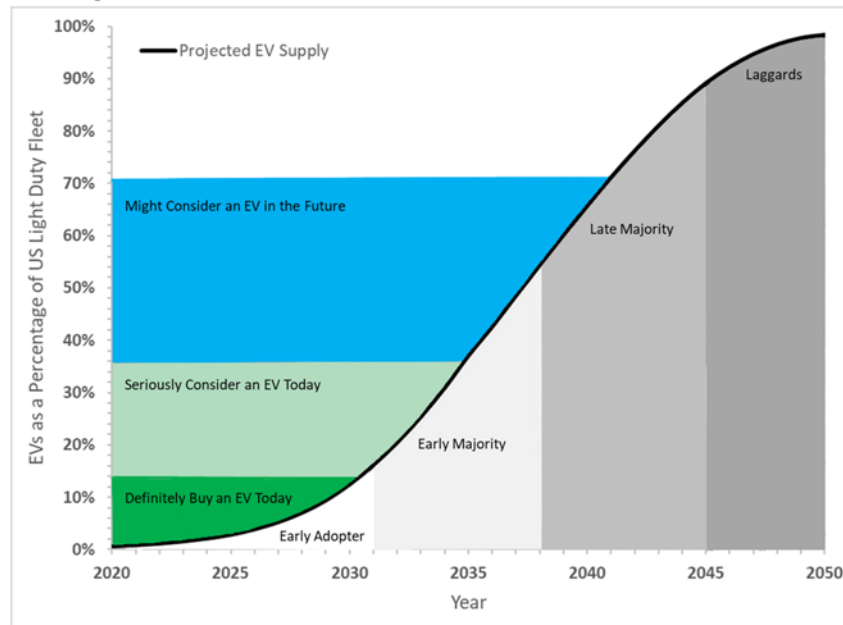


Figure 2 also includes survey data from Figure 1 showing when different levels of current demand are likely to be satisfied along this supply trajectory.¹¹ The plot shows that it will take until around 2030 before there is enough supply for all consumers who said in 2022 they would “definitely buy or lease an electric-only vehicle today.” Even in 2035, when new sales would be 100% electric under this scenario, supply would only be sufficient for all of the consumers who are currently “seriously considering” a BEV to buy one. The consumers who “might consider getting an electric-only vehicle in the future” will likely have to wait a long time for that

¹⁰ Consumer demand percentages are based upon results from the Nationally representative CR survey of 8,027 US adults conducted in January and February 2022. Consumer Reports, “Battery Electric Vehicles & Low Carbon Fuels Survey”, April 2022. Available at: https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July/2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf

¹¹ Nationally representative CR survey of 8,027 US adults conducted in January and February 2022. Consumer Reports, “Battery Electric Vehicles & Low Carbon Fuels Survey”, April 2022. Available at: https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July/2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf

opportunity, as there won't be enough supply for them to even start owning BEVs until after 2035.

The plot also includes the key stages of the textbook diffusion of innovation model,¹² which describes how new technologies typically spread through society. It is characterized by five key stages:¹³

- 1) Innovators (2.5%)¹⁴ - These are the earliest adopters who typically have a high risk tolerance and financial resources to absorb failures.
- 2) Early Adopters (13.5%) - The next adopters, typically younger, better educated and wealthier than average.
- 3) Early Majority (34%) - This group typically requires evidence that a technology works before adopting it.
- 4) Late Majority (34%) - This group tends to be skeptical of new technology and waits to adopt it until it has been proven to work and it has been adopted by the majority of the population.
- 5) Laggards (16%) - This group is very conservative with a strong aversion to change.

Figure 2 shows that on the modeled trajectory the market won't even leave the "early adopter" phase until around 2031, and demand for the "early majority" and "late majority" would not be satisfied until 2038 and 2045, respectively. So-called "laggards" won't become relevant to the market on this trajectory until the mid 2040s.

Of course, the GM-scenario supply trajectory modeled in Figure 2 is not the only possible trajectory for BEV adoption. For example, California has set zero-emissions vehicle (ZEV) standards, otherwise known as Advanced Clean Cars II (ACCII), that result in a more aggressive trajectory than the GM-scenario modeled above.¹⁵ ACCII calls for achieving 68% ZEV sales by 2030.¹⁶ This trajectory, assuming all ZEV sales are BEVs, is more in line with what has been observed in other countries that have exceeded 5% BEV sales, which has been a key tipping point in other markets around the world, according to a Bloomberg analysis of adoption

¹² On Digital Marketing, "The 5 Customer Segments of Technology," Available at: <https://ondigitalmarketing.com/learn/odm/foundations/5-customer-segments-technology-adoption/> and

Boston University School of Public Health, "Diffusion of Innovation Theory," Available at: <https://sphweb.bumc.bu.edu/otlt/mph-modules/sb/behavioralchangetheories/behavioralchangetheories4.html>

¹³ Each stage of adoption is associated with a specific percentage of the population, shown in parentheses below, based on the assumption of a normal distribution around the average time it takes for a population to adopt a specific technology.

¹⁴ Combined with the early adopters on the graph

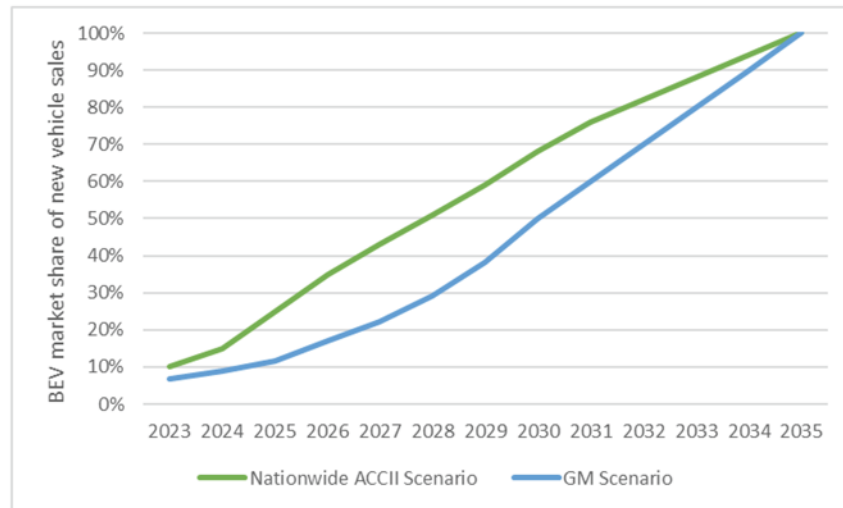
¹⁵ California Air Resources Board, "Advanced Clean Cars II Regulations: All New Passenger Vehicles Sold in California to be Zero Emissions by 2035" Available at:

<https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii>

¹⁶ California defines zero emission vehicles to include BEVs, fuel cell electric vehicles, and up to 20% plug in hybrid electric vehicles.

rates.¹⁷ If BEV supply nationwide were to accelerate to match the ACCII standards by 2026 and follow them to 2035, BEV penetration into the vehicle fleet could be accelerated by around two years, reducing the wait time for many consumers.¹⁸ This accelerated BEV sales scenario—"Nationwide ACCII"—is illustrated in Figure 3 compared to the GM scenario that was modeled in Figure 2.

Figure 3. Comparison of New BEV Sales Scenarios



¹⁷ Bloomberg, "US Crosses the Electric-Car Tipping Point for Mass Adoption," July 9, 2022. Available at: <https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone?smd=gr een&sref=JN1H0H2Z>

¹⁸ For example demand for early adopters would be satisfied by 2029 and the early majority by 2036.

A Virtuous Cycle

Four major trends make EV demand likely to grow far more quickly than EV supply: cost declines, improved infrastructure, increased consumer experience, and increased automaker investments. These trends tend to reinforce one another in a virtuous cycle. Here we'll examine them and their respective places in this dynamic one at a time.

Cost declines

Initial purchase cost is currently one of the top barriers to BEV ownership.¹⁹ Yet a combination of technological advancements, automaker efficiencies, economies of scale, and government tax incentives are helping to drive down the costs of BEVs. Many auto industry analysts and observers have estimated that cost parity between BEVs and conventional gasoline vehicles will be achieved sometime this decade. Recent analysis from the International Council on Clean Transportation (ICCT) estimated that even without any tax incentives, BEVs with 300 miles of range per charge will achieve cost parity in all light-duty vehicle classes before 2030.²⁰

What's more, the recently passed Inflation Reduction Act will offer tax credits of up to \$7,500 for the purchase of new BEVs that meet certain manufacturing, vehicle pricing, buyer income, and critical minerals requirements.²¹ A separate study from the ICCT estimated that these tax credits would make the average new BEV cheaper than the average new conventional vehicle as soon as 2023 and no later than 2025, resulting in a large boost in BEV demand.²²

Improved infrastructure

A major barrier to BEV adoption is the lack of widespread, reliable charging infrastructure.²³ The Bipartisan Infrastructure Law provided \$7.5 billion to help deploy BEV charging infrastructure throughout the country.²⁴ Also, as more BEVs are sold, there will be more demand for

¹⁹ Nationally representative CR survey of 8,027 US adults conducted in January and February 2022. Consumer Reports, "Battery Electric Vehicles & Low Carbon Fuels Survey", April 2022. Available at: https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf

²⁰ Peter Slowik, et al. "Assessment of Light-Duty Vehicle Cost and Consumer Benefits in the United States in the 2022-2035 Timeframe," The International Council on Clean Transportation, October 2022. Available at: <https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf>

²¹ Consumer Reports, "More SUVs, Teslas Now Qualify for the New Electric Vehicle Tax Credit," February 9, 2023. Available at: <https://www.consumerreports.org/cars/hybrids-evs/electric-vehicles-that-qualify-for-new-ev-tax-credit-a9310530660/>

²² Peter Slowik et al. "Analyzing the Impact of the Inflation Reduction Act on Electric Vehicles Uptake in the United States," The International Council on Clean Transportation, January 2023. Available at: <https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23-2.pdf>

²³ Nationally representative CR survey of 8,027 US adults conducted in January and February 2022. Consumer Reports, "Battery Electric Vehicles & Low Carbon Fuels Survey", April 2022. Available at: https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf

²⁴ ZETA, "The Final Rules: National Electric Vehicle Infrastructure Formula Program Summary," Available at: <https://www.zeta2030.org/insights/nevi-final-rule-summary>

infrastructure—and more revenue generated by it—which will likely help catalyze further private investment.

Furthermore, private corporations are beginning to see the opportunity that EV charging can provide. By installing chargers, businesses can influence where consumers spend their time (and money) while they wait for their vehicles to charge. For example, Starbucks is partnering with Volvo and ChargePoint to install fast chargers at 15 locations between Denver and Seattle.²⁵ Subway and GenZ EV Solutions are partnering to develop charging parks equipped with picnic tables, wifi, bathrooms, and playgrounds near some of Subway's locations.²⁶ As consumers become more confident in the availability and reliability of the charging network, their interest in purchasing a BEV is likely to increase.

Increased consumer experience

Direct experience with BEVs is one of the strongest drivers of purchase interest. This is illustrated in Figure 4, in which the three pie graphs represent low, medium, and high levels of experience with battery electric vehicles.²⁷ CR found that consumers with the most direct experience were almost ten times as likely to say they would “definitely buy” an electric vehicle today as consumers with no direct experience (58% vs 6%).²⁸ More BEVs on the road means more opportunities for Americans to gain more direct experience and exposure to BEVs. Right now, broad consumer experience with BEVs is very limited, but that is likely to change as more people see family, friends, and neighbors bring home their first battery electric vehicle.

²⁵ Starbucks, “Find an EV Charger at Starbucks stores from Seattle to Denver,” August 9, 2022. Available at: <https://stories.starbucks.com/stories/2022/find-an-ev-charger-at-starbucks-stores-from-seattle-to-denver/>

²⁶ Subway, “Subway Enhances Guest Experience with Plans to Add Electric Vehicle Charging Oasis Parks,” February 21, 2023. Available at: <https://newsroom.subway.com/2023-02-21-Subway-Restaurants>

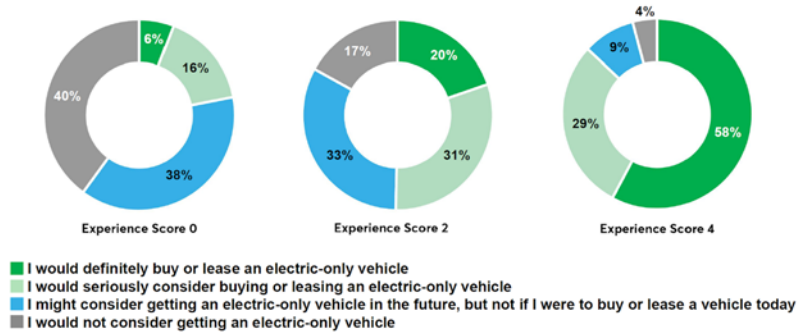
²⁷ Nationally representative CR survey of 8,027 US adults conducted in January and February 2022. Consumer Reports, “Battery Electric Vehicles & Low Carbon Fuels Survey”, April 2022. Available at: https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July/2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf

²⁸ Experience was measured based upon “yes” answers to four different questions:

- 1) Have you seen an EV in your neighborhood in the past month
- 2) Do you know someone with an EV
- 3) Have you been a passenger in an EV in the past year
- 4) Have you driven an EV in the past year

Figure 4. Survey Results on BEV Demand by Experience with BEVs

Which Statement below BEST describes your thoughts on buying or leasing an electric-only vehicle if you were to buy or lease a vehicle today?



Increased automaker investments

Finally, as purchase interest goes up, automakers are likely to respond by delivering more electric options, in more vehicle classes, and at more price points. We're already seeing significant growth in the number of BEV models that will become available to consumers over the next few years.²⁹ Many automakers have also significantly boosted their long term BEV commitments in recent years, and it seems likely that more will follow suit.³⁰ As of January 2023, automakers and battery makers plan to invest \$860B in the transition to EVs by 2030, including \$210B in the U.S, according to an analysis by Atlas Public Policy.³¹ As automakers deliver more volume, economies of scale and intensified competition for customers will further feed cost declines, which will feed back into the cycle and lead to increased BEV demand.

²⁹ Consumer Reports, "Hot, New Electric Cars That Are Coming Soon," March 15, 2023. Available at: <https://www.consumerreports.org/cars/hybrids-evs/hot-new-electric-cars-are-coming-soon-a1000197429/>

³⁰ Consumer Reports, "Automakers Are Adding Electric Vehicles to Their Lineups. Here's What's Coming." March 10, 2023. Available at: <https://www.consumerreports.org/cars/hybrids-evs/why-electric-cars-may-soon-flood-the-us-market-a9006292675/>

³¹ Atlas EV Hub, "\$210 Billion of Announced Investments in Electric Vehicle Manufacturing Headed for the U.S." January 12, 2023. Available at: https://www.atlasevhub.com/data_story/210-billion-of-announced-investments-in-electric-vehicle-manufacturing-headed-for-the-u-s/

Significant Risk to Automakers from Moving Too Slowly

The continuation of this virtuous cycle, however, is not assured. Consumers cannot buy vehicles that automakers don't build, so it is critical that automakers rapidly scale up BEV production to keep pace with growing demand. It remains unclear how consumers will respond if the supply of BEVs is insufficient to meet their demand. And it may prove disastrous for automakers to assume that consumers will buy whatever they build: CR's car buying survey from March and April 2022 found that 30% of licensed drivers who were then in the market to buy or lease a new (and not a used) vehicle were not even considering a conventional, non-hybrid vehicle.³² Given the demand dynamics discussed above, it seems unlikely that this number will stop growing anytime soon.

“ 30% of licensed drivers who were then in the market to buy or lease a new (and not a used) vehicle were not even considering a conventional, non-hybrid vehicle. ”

While this rapidly growing segment of consumers often cross-shops between battery-electric vehicles, plug-in hybrids, and hybrids, they no longer seem willing to settle for conventional internal combustion engine (ICE) vehicles—and may decide to put off their purchase rather than settle for one. In fact, the Osborne Effect is a well-documented phenomenon, in which consumers forgo the purchase of a soon-to-be-obsolete item while waiting for a newer and better version to become available.³³ Indeed, the long waitlists discussed above indicate that many buyers are already willing to wait years to get the vehicle they really want. Automakers may be able to entice some of these consumers to buy conventional gasoline vehicles, but doing so is likely to require discounting and may threaten profitability. Ultimately there are serious risks to automakers that fail to respond quickly to rapid growth in consumer demand for BEVs.

Analysis of sales data over the past few years further suggests that demand for ICE vehicles is already declining precipitously. Figure 5 shows annual U.S. light duty vehicle sales by powertrain type from 2018-2022. Sales of new ICE vehicles dropped by 26% from 2019 to 2022, while combined sales of BEVs, plug-in hybrid vehicles (PHEVs) and conventional hybrids increased by 144%. BEV sales alone increased by 244%.³⁴

³² Consumer Reports, "Car Buying: A National Representative Multi-Mode Survey, 2022 Results," May 2022. Available at: https://article.images.consumerreports.org/prod/content/dam/surveys/Consumer_Reports_Car_Buying_March_2022.pdf.

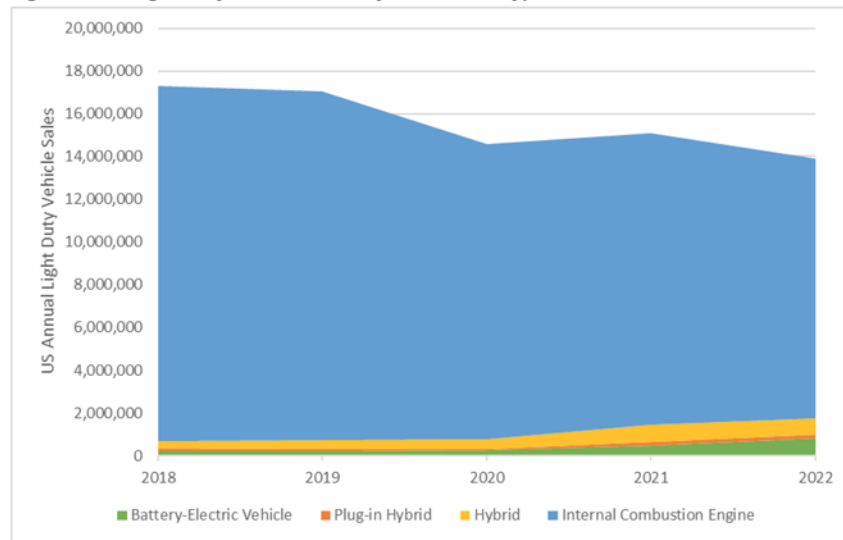
³³ Center for Computing History, "Osborne 1," available at: <https://www.computinghistory.org.uk/det/504/osborne-1/>.

³⁴ Consumer Reports analysis of Wards Intelligence annual sales data, available with subscription at: <https://wardsintelligence.informa.com/datacenter>

What's more, the increase in BEV, PHEV and hybrid sales did not even come close to offsetting the decline in ICE vehicle sales. Cumulative ICE vehicle sales between 2020 and 2022 fell by 9.4 million compared to the 2019 rate, while cumulative sales of BEVs, PHEVs, and hybrids increased by only 1.8 million.³⁵

It is impossible to determine what percentage of the reduction in ICE vehicle sales should be attributed to reduced demand vs. what percent are due to supply chain disruptions caused by the COVID-19 pandemic. However, pandemic-related supply chain issues have now largely been resolved, so the picture should soon become clear. Recent data showing both depressed sales of ICE vehicles and rapidly rising dealer inventories suggests that consumer demand for conventional vehicles is unlikely to rebound to prior levels.³⁶ As automakers seek to recover from pandemic related disruptions, they would be wise to focus their attention on boosting production of their more sustainable BEV, PHEV, and hybrid offerings.

Figure 5. US Light Duty Vehicle Sales by Powertrain Type 2018-2022



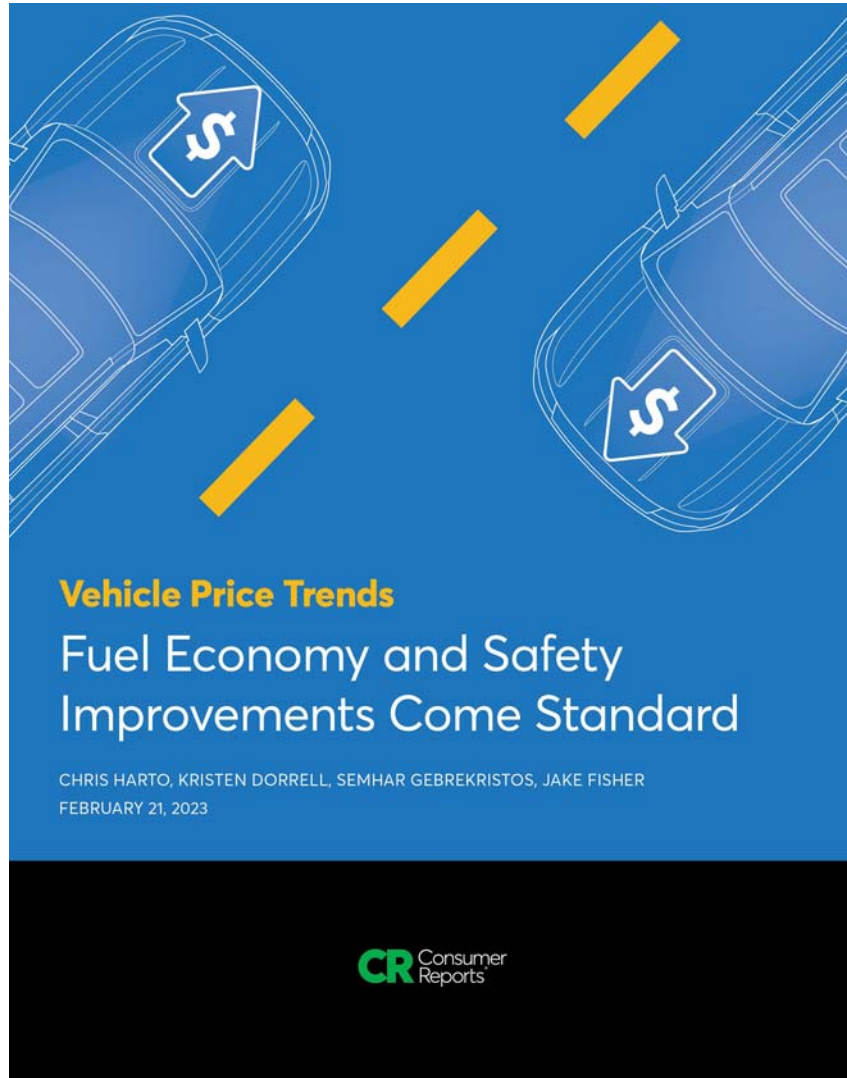
³⁵ Consumer Reports analysis of Wards Intelligence annual sales data, available with subscription at: <https://wardsintelligence.informa.com/datacenter>

³⁶ A total of 730,000 more vehicles were manufactured than sold between February 2023 and February 2022. <https://www.coxautoinc.com/market-insights/new-vehicle-inventory-february-2023/>

Time to Hit the Accelerator

The data point to one conclusion: it is time for both automakers and regulators to hit the accelerator on BEVs. Automakers have, at times, ignored market signals and done the bare minimum required of them by regulators.³⁷ The federal government, using the Environmental Protection Agency greenhouse gas standards and the National Highway Traffic Safety Administration corporate average fuel economy regulations, has an opportunity to help ensure that the industry stays on track, and doesn't fall too far behind rapidly growing consumer demand.

³⁷ Consumer Reports, "EPA Trends Report Shows Automakers Failed To Deliver Fuel Economy Gains Between Model Years 2020 and 2021," December 12, 2022. Available at: https://advocacy.consumerreports.org/press_release/epa-trends-report-shows-automakers-failed-to-deliver-fuel-economy-gains-between-model-years-2020-and-2021.



Executive Summary

Consumer Reports has a robust data set of real-world vehicle purchases made for our testing program over the past 40 years. A statistical analysis of this data from model years 2003 to 2021 found no systemic, statistically significant increase in inflation-adjusted vehicle prices across either vehicle classes or vehicle nameplates. Over this same time period, average fuel economy improved 30%, resulting in an average of \$7,000 in per-vehicle lifetime fuel savings for model year 2021 vehicles compared with model year 2003. Safety also significantly improved as crash-test procedures were strengthened, electronic stability control and backup cameras were mandated on new vehicles, and advanced driver assistance systems became more widely available. Commonly reported changes in average transaction prices appear to be primarily driven by shifts toward larger, more expensive SUVs and away from smaller and cheaper cars, rather than from the cost of technology improvements in individual models. These findings prove that regulators can and should be aggressive in ensuring that automakers continue to deliver cost-effective technology improvements that save dollars and lives.

1. Introduction

Consumers frequently say that safety and fuel economy are two of the most important features to them when purchasing a vehicle.¹ Yet opponents of strong efficiency, emissions, and safety standards often point to techno-economic analyses showing that adding technology to improve vehicles in these ways will increase vehicle prices and thereby harm consumers. These types of analyses are nearly always theoretical, estimating the incremental costs of specific technologies and extrapolating those cost increases into the future.² However, there have been very few studies that have attempted to look back at how real-world vehicle prices have changed over time in relation to efficiency, emissions, or safety standards. This study attempts to do just that, using data from Consumer Reports' (CR) automotive testing program. Each year CR purchases around 50 vehicles directly from dealers in the U.S. at retail prices. Records from these vehicle purchases over a nearly 40-year period provide a unique data set with which to study the evolution of vehicle prices over time.

¹ Consumer Reports, "Car Buying: A National Representative Multi-Mode Survey, 2022 Results," May 2022. Available at: https://article.images.consumerreports.org/prod/content/dam/surveys/Consumer_Reports_Car_Buying_March_2022.pdf.

² National Highway Traffic Safety Administration, "Cost and Weight Added by The Federal Motor Vehicle Safety Standards for MY1968-2012 Passenger Cars And LTVs," November 2017. Available at: <https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812354>, and David Shephardson, "Trump finalizes rollback of Obama-era vehicle fuel efficiency standards," Reuters, March 31, 2020. Available at: <https://www.reuters.com/article/us-usa-autos-emissions/trump-finalizes-rollback-of-obama-era-vehicle-fuel-efficiency-standards-idUSKBN21U25S>, and Thomas Pyle, "The Hidden Costs of Obama's Fuel Efficiency Standards," U.S. News and World Report, August 11, 2011. Available at: <https://www.usnews.com/opinion/blogs/on-energy/2011/08/11/new-fuel-standards-threaten-safety-affordability-and-comfort-for-consumers>.

2. Methodology

Vehicle purchase price data was collected from Consumer Reports' Auto Test Center (ATC) from as far back as 1983 until 2021. CR representatives purchase vehicles directly from U.S. dealers without identifying themselves as such, and generally select a popular, well-equipped trim version of each model, which is subsequently tested. To investigate whether or not vehicle prices have increased with vehicle fuel economy and greenhouse gas standards over time, the scope was limited to vehicles purchased by CR ATC with model years between 2003 and 2021, which overlaps with a period of significant improvement in both fuel economy and safety technology. The sample was further limited to vehicle nameplates that had been in existence for most of the selected time period. Vehicles with special trims that might skew the sample in one direction or another were removed from the sample. This resulted in a total sample of 362 vehicles.

The study period was ended after model year 2021 for two reasons. First, federal fuel economy and greenhouse gas regulations were significantly rolled back for model years 2021 and 2022, when automakers were required to make only negligible improvements.³ Second, this cutoff also enabled us to avoid the influence of significant supply chain disruptions from the COVID-19 pandemic, which have led to major short-term effects on vehicle prices.

All vehicles in the sample were categorized into seven classes: Compact Cars, Midsize Cars, Compact SUVs, Midsize SUVs, Large SUVs, Minivans, and Pickups. Vehicle purchase prices were adjusted to 2021 dollars using inflation factors taken from the consumer price index for all urban consumers (CPI-U) provided by the Bureau of Labor Statistics⁴ to allow for comparison over time. It is important to note that the prices of vehicles purchased by CR are only a proxy for market data on vehicle prices over time and are not necessarily representative of the entire market.

A simple linear regression model for vehicle purchase price in 2021 dollars vs. time in years was considered for each vehicle class as well as for individual makes/models. Hypothesis tests were used to evaluate whether or not CR ATC's vehicle purchase price had changed in a statistically significant manner ($\alpha = 0.05$) over time, grouped by vehicle class and by individual makes/models. With the sample data, it is not possible to causally link any significant changes in price with more stringent fuel economy or greenhouse gas standards. Thus, there is no statistical evidence to support the idea that the price has changed over time due to these causes.

³ Consumer Reports, "EPA Trends Report Shows Automakers Failed To Deliver Fuel Economy Gains Between Model Years 2020 and 2021," December 12, 2022. Available at: https://advocacy.consumerreports.org/press_release/epa-trends-report-shows-automakers-failed-to-deliver-fuel-economy-gains-between-model-years-2020-and-2021.

⁴ All vehicle prices were adjusted using the CPI value from January of their production year to January of 2021 using: U.S. Bureau of Labor Statistics, CPI for All Urban Consumers. Available at: <https://data.bls.gov/timeseries/CUUR0000SA0>.

We also considered a simple linear regression model for vehicle purchase price in 2021 dollars vs. vehicle fuel economy. Hypothesis tests were used to evaluate whether or not CR ATC's vehicle purchase price had changed significantly ($\alpha = 0.05$) with regard to changes in fuel economy, grouped by vehicle class. Again, it is not possible to determine a causal relationship between changes in vehicle purchase price and changes in vehicle fuel economy. However, in most cases, we do not observe increase in prices with increase in fuel-economy standards.

3. Vehicle Price Trend Results

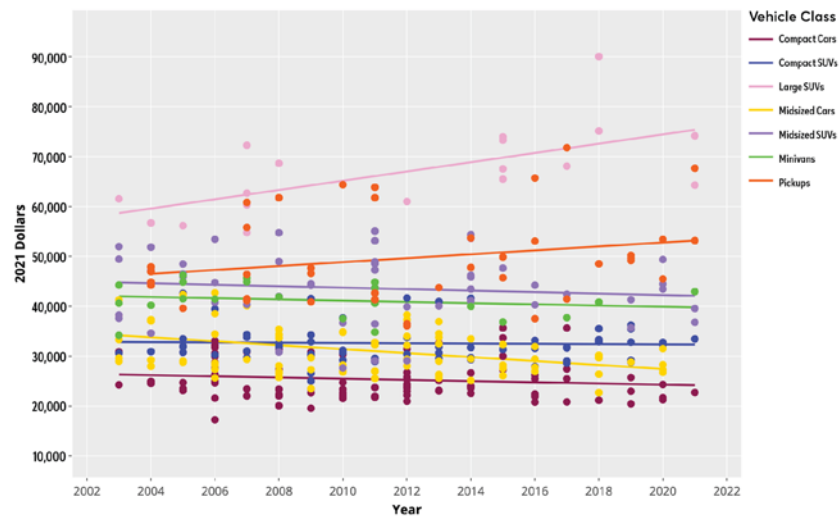
Statistical analysis of CR's purchase data from model years 2003 to 2021 showed no systemic, statistically significant change in vehicle prices over the period. Among seven vehicle classes, five showed no statistically significant change in price, one (Large SUVs) showed a statistically significant increase in price, and one (Midsized Cars) showed a statistically significant decrease in price.

In the instances where we did find a statistically significant change in vehicle price over time, there are other explanatory variables. For the Large SUVs class, it is posited that the observed increase in prices is likely due to more costly aesthetic and technological improvements. The Large SUVs class actually has seen the smallest improvement in fuel economy over the study period, even as many of these vehicles have been transformed from utilitarian blue-collar workhorses into near-luxury vehicles.

Figure 3.1 shows a scatter plot of the purchase data by vehicle class. Looking at the data from a vehicle nameplate perspective, 47 of 51 nameplates showed no statistically significant change in price, while two (the Ford Explorer, a midsized SUV, and the Ford F-150 pickup) showed a statistically significant price increase and two (the compact Volkswagen Jetta and midsized Volkswagen Passat) showed a statistically significant decrease.

See Appendix for details of the statistical analysis.

Figure 3.1 - Vehicle Purchase Price by Model Year in \$2021 by Vehicle Class



4. Market Trends

The results of the statistical analysis are counter to broadly reported narratives about increases in new-vehicle average transaction prices and “unaffordability” of new vehicles.⁵ The sorts of analysis that lead to those conclusions often rely on an overall average transaction price, and typically do not adjust for inflation. While average transaction price can be a useful metric, it doesn’t capture many of the underlying dynamics in the market.

One of the key dynamics that is missed when focusing on averages is the rapid shift in the market away from less expensive smaller cars to larger and more expensive crossovers and SUVs. Figure 4.1 illustrates changes in market share by different vehicle classes from the Environmental Protection Agency’s annual Automotive Trends Report.⁶ The EPA data uses slightly different vehicle classes: It relies on regulatory categories. All types of cars are lumped together in one vehicle class. SUVs are separated into “car SUV” and “truck SUV.” Car SUVs include smaller SUVs that are 2-wheel drive, while truck SUVs include larger/heavier SUVs and SUVs that have certain offroad capabilities, including 4-wheel drive. Sales of both types of SUVs combined have more than doubled from 26% to 56% of the overall auto market over the study period, while car sales have fallen by nearly half from 50% to 26% of the market. Given the higher average prices of SUVs than cars, this appears to be one of the primary reasons that average transaction prices have increased over the years.

How much of this shift from cars to SUVs has been driven by automakers vs. consumer preferences is still an open question that this report does not attempt to answer. Whatever the underlying reason, some automakers have virtually stopped selling small cars.⁷

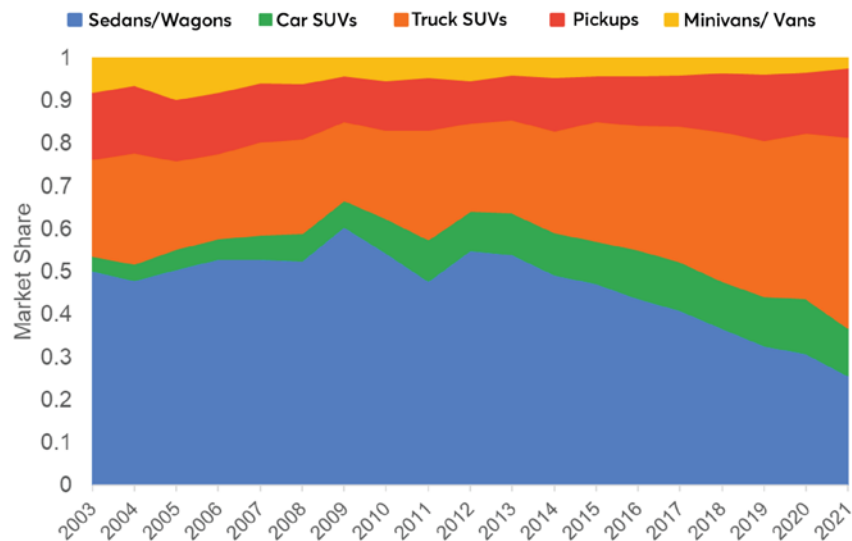
⁵ Sean Szymkowski, “Average new car price crosses \$40,000 in 2020 and that’s nuts,” CNET, January 13, 2021. Available at: <https://www.cnet.com/roadshow/news/average-new-car-price-2020>, and Anna Hecht, “Car prices are increasing—here’s how that can hurt Americans,” CNBC, October 22, 2019. Available at: <https://www.cnbc.com/2019/10/22/car-prices-are-rapidly-increasing-heres-why-thats-bad-for-americans.html>, and

Kelley Blue Book, “Average New-Car Prices Rise Nearly 4 Percent For January 2018 On Shifting Sales Mix, According To Kelley Blue Book,” February 1, 2018. Available at: <https://mediaroom.kbb.com/2018-02-01-Average-New-Car-Prices-Rise-Nearly-4-Percent-For-January-2018-On-Shifting-Sales-Mix-According-To-Kelley-Blue-Book>.

⁶ U.S. Environmental Protection Agency, 2022 EPA Automotive Trends Report. Data available at: www.epa.gov/automotive-trends/explore-automotive-trends-data. Accessed January 23, 2023.

⁷ Erik Shilling, “Ford And GM’s Decision To Abandon Small Cars Is Already Costing Them,” Jalopnik, November 14, 2019. Available at: <https://jalopnik.com/ford-and-gms-decision-to-abandon-small-cars-is-already-1839858417>.

Figure 4.1 - Market Share by Vehicle Class
From MY'03 to MY'21

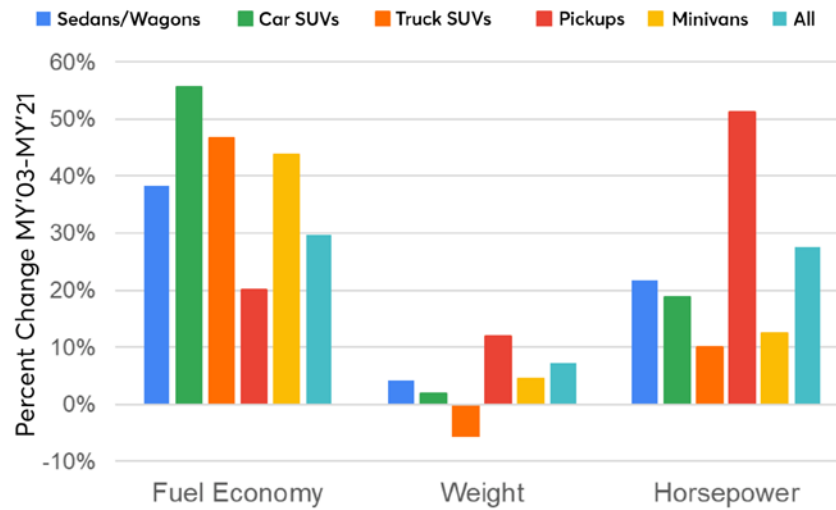


The EPA Automotive Trends Report also tracks changes in vehicle fuel economy, weight, and horsepower. Changes in these characteristics over the study period are shown in Figure 4.2.⁸ It illustrates that vehicles in every class have gotten significantly more efficient while simultaneously becoming more powerful. The data also shows that vehicles in most classes have gotten slightly heavier, which likely translates into slight increases in size, with the exception of truck SUVs, which have gotten slightly lighter. This is potentially due to a shift from more truck-like body-on-frame SUVs to more car-like, unibody crossovers.⁹

⁸ U.S. Environmental Protection Agency, 2022 EPA Automotive Trends Report. Data available at: www.epa.gov/automotive-trends/explore-automotive-trends-data. Accessed January 23, 2023.

⁹ Consumer Reports, "The Rise of the Crossover: The segment that's really driving the auto industry's sales," December 19, 2019. Available at: <https://advocacy.consumerreports.org/research/the-rise-of-the-crossover-the-segment-thats-really-driving-the-auto-industrys-sales>.

Figure 4.2 - Changes in Vehicle Fuel Economy, Weight, and Horsepower From MY'03-MY'21



This general market shift toward larger vehicle classes has come with more than just an increase in sticker prices. The shift from smaller, more efficient vehicles to larger, less efficient vehicles has also eroded some of the potential fuel savings and emissions benefits of the efficiency improvements made on a vehicle-by-vehicle basis. If the fleet mix had remained the same as it was in 2003, overall fleet-wide average fuel economy would have improved by 43% instead of 30%. There are also potential safety implications. CR has found that larger vehicles generally have a harder time avoiding crashes and perform worse in our emergency handling and braking tests. Further, CR and other research have found that larger vehicles pose greater risks to both pedestrians and people in other cars than smaller cars do.¹⁰

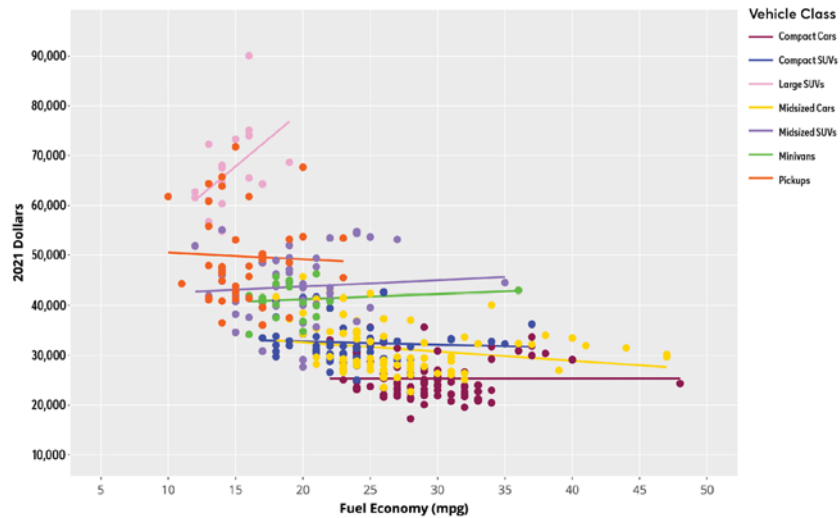
¹⁰ Consumer Reports, "The Hidden Danger of BIG Trucks," June 8, 2021. Available at: <https://www.consumerreports.org/car-safety/the-hidden-dangers-of-big-trucks>.

5. Improvements in Fuel Economy

Statistical analysis of price vs. fuel economy comes to similar conclusions as the statistical analysis of price vs. time as described in section 3—namely, little to no change in vehicle price relative to increased fuel economy.

Results of this analysis are shown in Figure 5.1. Of the seven vehicle classes analyzed, one (Large SUVs) showed a statistically significant increase in price as fuel economy increases, and one (Midsize Cars) showed a statistically significant decrease in price as fuel economy increases. The remaining vehicle classes showed no statistically significant change in price relative to fuel economy.

Figure 5.1 - Statistical Analysis of Vehicle Purchase Price vs. Fuel Economy



Given that there is likely to be a strong correlation between fuel economy and model year—due to strong fuel economy and greenhouse gas standards in place during most of the study period—it is not surprising that the results for fuel economy and model year are similar.¹¹ This is illustrated in Figure 5.2, which shows improvements in average fuel economy by vehicle class over the study period. Every vehicle class shows nearly continuous incremental improvements in fuel economy over this period (these results are also presented numerically in Table 5.1). Fuel-economy improvement over the study period ranged from 20% for pickups to 56% for car SUVs.

These improvements were also translated by CR into an estimated lifetime fuel cost savings for model year 2021 vehicles, assuming a constant gasoline price of \$3/gallon and a vehicle lifetime of 200,000 miles. In terms of fuel savings, the cumulative improvements result in consumers spending between \$6,200 less on fuel for pickups to almost \$11,600 less on fuel for truck SUVs than they would have if fuel economy had remained flat at 2003 levels.

The historical data indicates that flat fuel economy is exactly what automakers would have delivered if not for strong fuel economy and greenhouse gas standards. Going back to the beginning of the CAFE program in the mid-'70s, there have been three distinct periods:

1. From the mid-'70s to the mid-'80s, a large increase in CAFE standards drove an increase in average passenger vehicle fuel economy from about 13.5 mpg in 1975 to 21.3 mpg in 1985.¹²
2. Standards stagnated in the mid-'80s with no required improvement until 2005. Over this period average fuel economy dropped from 21.3 mpg in 1985 to 19.3 mpg in 2004.¹³
3. Standards began increasing again in 2005 and have continued increasing through 2021, despite efforts to roll back standards.¹⁴

The data is clear that strong federal fuel economy and greenhouse gas standards work, and deliver huge savings to consumers. Based upon the statistical analysis in this study, we can now conclude that these savings have come with no statistically significant, inflation-adjusted cost to consumers in terms of vehicle purchase price.

¹¹ U.S. Department of Energy, Alternative Fuels Data Center, "Vehicle Fuel Efficiency (CAFE) Requirements by Year." Available at: <https://afdc.energy.gov/data/10562>, accurate through model year 2020. See Federal Register, "The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks," April 30, 2020. Available at: <https://www.federalregister.gov/d/2020-06967>, for standards through model years 2021 and 2022.

¹² PEW, "Driving to 54.5 MPG: The History of Fuel Economy," Fact Sheet, April 20, 2011. Available at: <https://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2011/04/20/driving-to-545-mpg-the-history-of-fuel-economy>.

¹³ U.S. Environmental Protection Agency, 2022 EPA Automotive Trends Report. Data available at: www.epa.gov/automotive-trends/explore-automotive-trends-data. Accessed January 23, 2023.

¹⁴ Consumer Reports, "Consumer Reports: White House roll back of gas mileage rules compounds financial problems for consumers with economy on brink of recession," March 31, 2020. Available at: https://advocacy.consumerreports.org/press_release/consumer-reports-white-house-roll-back-of-gas-mileage-rules-compounds-financial-problems-for-consumers-with-economy-on-brink-of-recession.

Figure 5.2 - Average Fuel Economy by Vehicle Class by Model Year

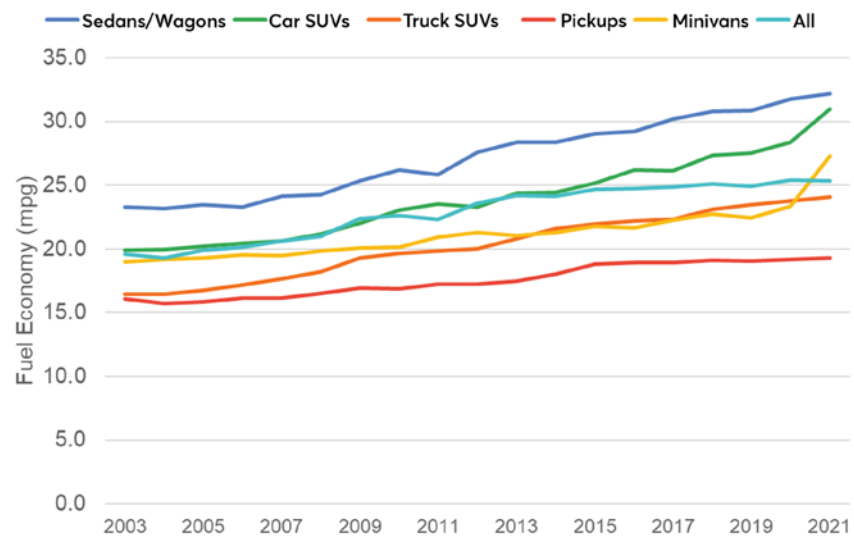


Table 5.1 - Fuel Economy Improvements and Consumer Savings From MY'03 to MY'21

Vehicle Class	2003 Fuel Economy	2021 Fuel Economy	Percent Change	Lifetime Fuel Savings
Sedans/Wagons	23.3	32.2	38%	\$7,100
Car SUVs	19.9	31.0	56%	\$10,800
Truck SUVs	16.4	24.1	47%	\$11,600
Pickups	16.1	19.3	20%	\$6,200
Minivans	19.0	27.3	44%	\$9,600
All	19.6	25.4	30%	\$7,000 ⁹

6. Improvements in Safety Technology

Fuel economy is not the only attribute of vehicles that has improved over the course of the study period. Safety has improved significantly as well. The fatality rate per 100 million vehicle miles traveled decreased 25% from 2003 to 2019.¹⁵ In terms of population, the fatality rate decreased from 14.78 per 100,000 people in 2003 to 11.07 in 2019, which also marks a 25% decrease.¹⁶ Fatality rates did increase significantly in 2020 and remained high in 2021, but the National Highway Traffic Safety Administration (NHTSA) attributes this increase largely to an increase in risky behavior—including reduced seatbelt usage, increased speeding, and increased impaired driving—during the COVID-19 pandemic.¹⁷ According to the latest data from NHTSA, traffic deaths remained stubbornly high for the first nine months of 2022, though they were 0.2% lower compared with the same time frame in 2021.

Numerous new safety features have been developed and widely deployed on new vehicles throughout the study period. Electronic stability control, which helps drivers maintain control of their vehicles in difficult conditions, was required to be standard on all new passenger vehicles starting in September 2011.¹⁸ Backup cameras, which increase rear visibility and can prevent backover incidents, were required to be standard on all new passenger vehicles starting in May 2018.¹⁹ While frontal airbags started being widely deployed in the late 1980s and were first mandated for both the driver and passenger in the 1999 model year, automakers have continued to expand the use of airbags to include side airbags, which are now standard on most vehicles in order to meet federal side-impact protection standards, even though they are not specifically required by law.²⁰

Advanced driver assistance systems (ADAS) have also been developed and more widely adopted in recent years, and are showing real-world benefits.²¹ Some of the most common

¹⁵ National Highway Traffic Safety Administration, Motor Vehicle Traffic Fatalities and Fatality Rates 1899-2020, June 2022. Available at: <https://cdan.nhtsa.gov/tstables/Fatalities%20and%20Fatality%20Rates.pdf>.

¹⁶ National Highway Traffic Safety Administration, FARS Data Tables. Available at: <https://www.fars.nhtsa.dot.gov/Main/index.aspx>.

¹⁷ National Highway Traffic Safety Administration, "2020 Fatality Data Show Increased Traffic Fatalities During Pandemic," June 3, 2021. Available at: <https://www.nhtsa.gov/press-releases/2020-fatality-data-show-increased-traffic-fatalities-during-pandemic>, and National Highway Traffic Safety Administration, "Newly Released Estimates Show Traffic Fatalities Reached a 16-Year High in 2021," May 17, 2022. Available at: <https://www.nhtsa.gov/press-releases/early-estimate-2021-traffic-fatalities>.

¹⁸ National Highway Traffic Safety Administration, "Newer Cars Are Safer Cars." Available at: <https://www.nhtsa.gov/newer-cars-are-safer-cars>.

¹⁹ National Highway Traffic Safety Administration, "Newer Cars Are Safer Cars." Available at: <https://www.nhtsa.gov/newer-cars-are-safer-cars>.

²⁰ *Id.*; Insurance Institute for Highway Safety, "Airbags." Available at: <https://www.iihs.org/topics/airbags#overview>.

²¹ Insurance Institute for Highway Safety, "Real-world benefits of crash avoidance technologies," December 2020. Available at: <https://www.iihs.org/media/259e5bbd-f859-42a7-bd54-3888f7a2d3ef/e9boUQ/Topics/ADVANCED%20DRIVER%20ASSISTANCE/IIHS-real-world-CA-benefits.pdf>.

ADAS systems are automatic emergency braking (AEB), pedestrian detection, lane departure warning, and blind spot warning. Consumer Reports estimates that the inclusion of all four of these safety systems on all vehicles could save around 11,800 lives per year.²² While these safety systems are not yet required to be installed on vehicles—NHTSA is currently drafting proposed rules to require AEB with pedestrian detection and lane departure warning/lane keeping assistance systems on passenger vehicles, pursuant to the 2021 Infrastructure Investment and Jobs Act²³—as of May 2018, at least one ADAS system was available on 92.7% of all new vehicles on the market in the U.S.²⁴ A total of 20 automakers voluntarily committed to installing city-speed AEB on at least 95% of the passenger vehicles they sell for the U.S. market. As of 2021, twelve automakers had met that commitment, and by 2022, fifteen had done so.²⁵

Crash-test protocols were also significantly strengthened after model year 2010. NHTSA enhanced its crash-test ratings system by adding an additional crash test, adding a smaller dummy to some tests to approximate the size of a 5th-percentile adult female, adding additional sensors to the dummies, and introducing a new overall 5-star safety rating.²⁶ Together these changes made it more difficult for automakers to achieve the top rating, encouraging further improvements in vehicle crashworthiness.

Given the findings of this study, it appears that all of these life-saving improvements in vehicle safety technology have been delivered without any statistically significant increase in inflation-adjusted vehicle cost.

²² Consumer Reports, "New Consumer Reports analysis finds existing vehicle safety technologies could cut road deaths in half if they came standard on every vehicle," June 29, 2020. Available at: https://advocacy.consumerreports.org/press_release/new-consumer-reports-analysis-finds-existing-vehicle-safety-technologies-could-cut-road-deaths-in-half-if-they-came-standard-on-every-vehicle.

²³ Office of Management and Budget, Office of Information and Regulatory Affairs, "Light Vehicle Automatic Emergency Braking (AEB) with Pedestrian AEB." Available at: <https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202210&RIN=2127-AM37>, and Office of Management and Budget, Office of Information and Regulatory Affairs, "Minimum Performance Standards for Lane Departure Warning and Lane-Keeping Assist Systems." Available at: <https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202210&RIN=2127-AM52>.

²⁴ American Automobile Association, "Advanced Driver Assistance Technology Names," January 2019. Available at: <https://www.aaa.com/AAA/common/AAR/files/ADAS-Technology-Names-Research-Report.pdf>.

²⁵ Insurance Institute for Highway Safety, "Two more automakers cross finish line in race to fulfill autobrake pledge," December 17, 2021. Available at: <https://www.iihs.org/news/detail/two-more-automakers-cross-finish-line-in-race-to-fulfill-autobrake-pledge>, and Insurance Institute for Highway Safety, "Three more automakers fulfill pledge to make autobrake nearly universal," December 8, 2022. Available at: <https://www.iihs.org/news/detail/three-more-automakers-fulfill-pledge-to-make-autobrake-nearly-universal>.

²⁶ Consumer Reports, "NHTSA crash test 101: How crash worthiness is measured and how crash ratings can help you choose your next car," April 2014. Available at: <https://www.consumerreports.org/cro/2011/08/crash-test-101/index.htm>, and Ronald Montoya, "NHTSA Revises Five-Star Safety Ratings," Edmunds, October 1, 2010. Available at: <https://www.edmunds.com/car-safety/nhtsa-revises-five-star-safety-ratings.html>.

Conclusions

The data is clear that strong federal fuel economy and greenhouse gas standards work, and deliver huge savings to consumers. Based upon the statistical analysis in this study, we can now conclude that these savings have come with no statistically significant, inflation-adjusted cost to consumers in terms of increased vehicle purchase price. In addition to more efficient vehicles, consumers are also getting safer vehicles as the result of improved safety standards—all without paying more on an inflation-adjusted basis.

Reported changes in average automotive transaction prices appear to be primarily driven by automaker and consumer shifts toward larger, more expensive SUVs and away from smaller and cheaper cars, rather than by improvements in fuel economy or safety technology. The CR data presented illustrate that on a same vehicle nameplate or same vehicle class basis, new vehicle prices have seen no systemic increase. At the same time, these vehicles have become safer, less polluting, more efficient, and more capable.

While significant improvements have been made, the work is not done. These findings demonstrate that regulators can and should be aggressive in ensuring that automakers continue to deliver cost-effective technology improvements that save dollars and lives.²⁷

²⁷ Consumer Reports, "Vehicle Emissions Standards Fact Sheet," March 2021. Available at: <https://advocacy.consumerreports.org/wp-content/uploads/2021/03/Consumer-Reports-Vehicle-Emissions-Standards-Fact-Sheet-3.22.21-FINAL.pdf>, and National Highway Traffic Safety Administration, Motor Vehicle Traffic Fatalities and Fatality Rates 1899-2020, June 2022. Available at: <https://cdan.nhtsa.gov/tsftables/Fatalities%20and%20Fatality%20Rates.pdf>.

Appendix

Table A.1 Results of the Regression Analysis of Vehicle Price vs. Year by Vehicle Class

Vehicle Class	Slope Estimate for Year	95% Confidence Interval	p-Value
Compact Cars	-120	(-303, 64)	0.1994
Compact SUVs	-27	(-226, 171)	0.7830
Large SUVs	928	(355, 1501)	0.0033
Midsized Cars	-396	(-613, -180)	0.0005
Midsized SUVs	-147	(-516, 221)	0.4258
Minivans	-123	(-432, 186)	0.4143
Pickups	393	(-163, 949)	0.1609

Table A.2 Results of the Regression Analysis of Vehicle Price vs. Year by Vehicle Nameplate

Make/Model	Slope Estimate for Year	95% Confidence Interval	p-Value
Compact Cars			
Ford Focus	525	(-113, 1163)	0.0957
Honda Civic	-323	(-646, 1)	0.0505
Hyundai Elantra	-69	(-199, 61)	0.2512
Kia Forte	-188	(-589, 213)	0.2327
Mazda Mazda3	-23	(-390, 345)	0.8889
Nissan Sentra	-288	(-736, 159)	0.1481
Subaru Impreza	-408	(-1223, 408)	0.2758
Toyota Corolla	-4	(-391, 382)	0.9763
Volkswagen Golf	420	(-689, 1530)	0.3750
Volkswagen Jetta	-609	(-1180, -38)	0.0392
Compact SUVs			

Chevrolet Equinox	118	(-608, 844)	0.6928
Ford Escape	-174	(-759, 412)	0.5136
Honda CR-V	-5	(-197, 188)	0.9535
Hyundai Tucson	-162	(-467, 142)	0.1485
Jeep Cherokee	-43	(-26219, 26133)	0.9867
Kia Sportage	-84	(-1821, 1652)	0.8543
Mazda CX-5	179	(-2520, 2878)	0.5549
Nissan Rogue	76	(-1259, 1411)	0.6017
Subaru Forester	-142	(-716, 432)	0.5768
Toyota RAV4	-3	(-580, 575)	0.9918
Volkswagen Tiguan	-1032	(-5733, 3668)	0.2190
Large SUVs			
Chevrolet Suburban	1187	(-69, 2442)	0.0555
Chevrolet Tahoe	254	(-1326, 1834)	0.6447

Ford Expedition	827	(-169, 1823)	0.0701
Lincoln Navigator	1310	(-13544, 16164)	0.4639
Nissan Armada	844	(-2158, 3846)	0.1738
Midsized Cars			
Chevrolet Malibu	274	(-239, 786)	0.2580
Honda Accord	-369	(-955, 217)	0.1956
Hyundai Sonata	-63	(-519, 393)	0.7640
Mazda Mazda6	-702	(-10150, 8747)	0.5184
Nissan Altima	-381	(-1205, 443)	0.3172
Subaru Legacy	-429	(-1301, 443)	0.2740
Toyota Camry	-424	(-1174, 327)	0.2335
Volkswagen Passat	-862	(-1424, -300)	0.0071
Midsized SUVs			
Dodge Durango	-158	(-2609, 2293)	0.8508

Ford Explorer	587	(32, 1143)	0.0435
Honda Pilot	-558	(-1427, 311)	0.1337
Hyundai Santa Fe	6	(-1149, 1161)	0.9891
Jeep Grand Cherokee	669	(-667, 2006)	0.2367
Kia Sorento	366	(-240, 972)	0.2011
Nissan Murano	-253	(-1895, 1389)	0.5755
Toyota Highlander	-521	(-1079, 38)	0.0637
Minivans			
Dodge Grand Caravan	244	(-873, 1360)	0.2202
Honda Odyssey	-301	(-625, 24)	0.0600
Kia Sedona	51	(-1697, 1799)	0.9116
Toyota Sienna	-221	(-817, 375)	0.4098
Pickups			

Chevrolet Silverado	285	(-880, 1450)	0.5881
Dodge Ram	-8	(-1188, 1172)	0.9880
Ford F-150	928	(137, 1720)	0.0269
Ford F-250	1192	(-4058, 6442)	0.2124
Nissan Titan	-80	(-3803, 3643)	0.9346
Toyota Tacoma	-226	(-3085, 2634)	0.4992

Table A.3 Results of the Regression Analysis of Vehicle Price vs. Fuel Economy by Vehicle Class

Vehicle Class	Slope Estimate for Fuel Economy	95% Confidence Interval	p-Value
Compact Cars	0	(-194, 195)	0.9963
Compact SUVs	-63	(-304, 178)	0.6035
Large SUVs	2257	(202, 4312)	0.0332
Midsized Cars	-184	(-365, -4)	0.0457
Midsized SUVs	127	(-361, 614)	0.6040
Minivans	100	(-303, 503)	0.6102
Pickups	-133	(-1191, 925)	0.8001

Senate Committee on Environment and Public Works
Subcommittee on Clean Air, Climate, and Nuclear Safety
Hearing Entitled, “Cleaner Vehicles: Good for Consumers and Public Health”
April 18, 2023
Questions for the Record - Chris Harto

Ex-Officio Chairman Carper:

1. Many communities of color and low-income families live in areas with very high levels of air pollution from cars and trucks. These communities experience disproportionate pollution exposures, and disproportionate harms to their health.
 - a. How will the Environmental Protection Agency’s (EPA) proposed greenhouse gas emissions standards reduce these disproportionate air pollution harms?

Due to redlining and other historically discriminatory housing and transportation policies, low-income and overburdened communities are disproportionately forced to live in areas near highways, ports, warehouses, and other high-transportation corridors where air pollution is most severe. A recent CR investigation¹ shows just how severe the impact of last-mile shipping facilities is on communities in California’s San Gabriel Valley. Increased deployment of electrification in all forms of transportation will reduce air pollution in our most vulnerable communities.

EPA’s multi-pollutant standards will significantly reduce these overall harms from transportation. EPA estimates that the light-duty multi-pollutant standards will deliver around \$330 billion in climate benefits and \$140-\$280 billion in reduced harm from criteria air pollutants. EPA’s heavy-duty greenhouse gas and NOx standards will deliver additional climate and health benefits. While overburdened communities have disproportionately borne the brunt of these harms, they will also benefit the most from their reduction.

- b. How will the clean vehicle investments included in the Inflation Reduction Act and the Bipartisan Infrastructure Law help to advance equitable access to clean, zero-emission vehicles in communities historically overburdened with transportation pollution?

The Inflation Reduction Act (IRA) includes tax credits for both new and used electric vehicles (EVs), making cleaner vehicles more affordable, while the Bipartisan Infrastructure Law (BIL) dedicates funding for the deployment of infrastructure in overburdened and disadvantaged communities.

¹ Consumer Reports, *When Amazon Expands, These Communities Pay the Price*, December 9, 2021, <https://www.consumerreports.org/corporate-accountability/when-amazon-expands-these-communities-pay-the-price-a2554249208/>.

Notably, the IRA's used EV tax credit will help to ensure a robust secondary EV market, as 70% of consumers buy their cars on the used car market. This credit will be especially helpful for low-income communities, which traditionally rely on the secondary market for their vehicle purchases. Additional provisions in the IRA that allow EV tax credits to go directly to dealerships will ensure greater benefit to low-income consumers who do not have the tax liability to benefit from the entirety of the tax credit. Historically, since these tax credits are non-refundable, consumers who do not have a tax liability of \$7,500 or above would only receive the tax credit to match their liability. This shift will enable consumers to see immediate savings from the incentive up to the maximum tax credit for their vehicle of choice.

The Bipartisan Infrastructure Law complements the IRA tax incentives by further investing \$7.5 billion in EV charging. This will contribute to the Biden Administration's goal of completing a national network of 500,000 EV chargers by 2030.

2. Please provide an example of where you believe there is common ground among all witnesses who testified before the Committee for this hearing.

One area of broad agreement is that electric vehicles can help reduce emissions, but that one major barrier to widespread adoption is the lack of widespread, reliable charging infrastructure. Thankfully, as mentioned above, the BIL provides \$7.5 billion to help deploy EV charging infrastructure throughout the country. Additionally, as more EVs are sold with the incentives from the IRA, demand for infrastructure will enable further investment from the private sector. As mentioned in my testimony, corporations are already identifying and acting on opportunities to build chargers - Walmart, 7-11, Starbucks, and Subway have all recently announced major EV charging initiatives. As consumers become more confident in the availability and reliability of the charging network, they are likely to become more comfortable with the idea of owning an EV. In sum, between the increase of both public and private investments dedicated to building out a national charging network, this challenge is likely to be overcome in the near future.

Is there anything else that you would like to provide the Committee that was not included in your testimony or discussed during the hearing?

Following the hearing I dug into the details of EPA's proposal and ran some modeling to address questions from the hearing about different compliance pathways. EPA's proposed rule is a technology-neutral performance standard. EPA's modeling estimates that the pathway that maximizes overall net benefits is one in which automakers comply almost entirely through the deployment of battery electric vehicles (BEVs). This makes sense due to the roughly \$15,000 in

lifetime fuel and maintenance savings BEVs can deliver to consumers². However, this is not the only feasible compliance pathway.

CR's modeling shows that automakers can also comply with these rules by building between 50-55% BEVs by 2032, well within the existing plans and commitments of many automakers, as long as they continue to make incremental improvements to their remaining internal combustion engine (ICE) fleets and build modest numbers of plug-in hybrid vehicles. Improvements to ICE fleets may not even require deployment of new technologies, but merely prioritizing the retirement of their highest-emitting powertrains, while focusing on production of their lowest-emitting powertrains.

Automakers that chose to invest heavily in hybrid and plug-in hybrid models can potentially comply with BEV deployments under 40% of their fleets. This diversity in compliance pathways is good for consumers, and will give Americans more choices to save money while reducing their emissions.

Senator Kelly:

1. As we look towards the future of cleaner vehicles, it's important we think about how to maximize their benefits for consumers and our climate. One key metric that stands out for this purpose is efficiency. Higher levels of efficiency mean that an EV can travel further while using less energy, enabling electric vehicles to travel longer distances with smaller batteries and less demand on the grid. How would more energy efficient electric vehicles help to lower range anxiety among consumers and also decrease the cost of electric vehicles over time?

Improving the efficiency of electric vehicles means more range and fewer batteries, which therefore means lower costs and fewer critical minerals. It also means fewer upstream emissions and less impact on the grid. Efficiency improvements will allow EVs to travel longer distances with the same sized battery, helping to reduce range anxiety and speed up charging times. While there are limits to how efficient an EV can get, there is still significant room for improvement on efficiency for the average EV today.

² Consumer Reports, *Vehicle Emission Standards Fact Sheet*, March 2021, <https://advocacy.consumerreports.org/wp-content/uploads/2021/03/Consumer-Reports-Vehicle-Emissions-Standards-Fact-Sheet-3.22.21-FINAL.pdf>

Ranking Member Ricketts:

1. In your spoken testimony, you shared “U.S. DOE Research Labs ... have done this type of analysis. I know at least for the light duty vehicles sector, were looking at an increase and growth in generation and demand of about 1% per year.”

In truth, this specific statistic is not published in any report. It is based on the various DOE quotes and reports that state that full electrification of transportation would require about a 25% increase in electricity generation. In Consumer Reports own report “Excess Demand- The Looming EV Shortage”, figure 2 shows that even at 100% EV sales in 2035 it will take until at least 2050 for almost all vehicles to be electric.

You extrapolated from these statistics that 25% increase in demand divided by 27 years to achieve the level of electrification is approximately 1% per year.

These reports were also published before the release of the Proposed Rule: Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles.

- a) Mr. Harto, can you elaborate on why you chose to misrepresent these statistics to our subcommittee?

The data I provided you and your staff supports my statement that full electrification of the light duty vehicle sector would result in growth in electricity demand of about 1% per year.³ What's more, your question inspired me to do some additional research and publish a blog post with new analysis that confirms the numbers that I presented in my testimony. In that blog I also present calculations that show that full compliance with the proposed EPA standards by automakers utilizing only battery electric vehicles as a compliance pathway (instead of also utilizing other available technologies such as hybrid vehicles and improvements to average gasoline vehicle efficiency) would only result in a 6% increase in US electricity demand through 2032.

A link to this blog post is included below and I have attached the full text of that blog post as a PDF to be submitted for the record.

<https://advocacy.consumerreports.org/research/blog-can-the-grid-handle-evs-yes/>

³U.S. DRIVE Grid Integration Technical Team and Integrated Systems Analysis Technical Team, *Summary Report on EVs at Scale and the U.S. Electric Power System*, November 2019, <https://www.energy.gov/eere/vehicles/articles/summary-report-evs-scale-and-us-electric-power-system-2019>.

Senator MARKEY. Thank you, Mr. Harto.

Finally, we are going to hear from Andrew Boyle from the American Trucking Association. Welcome.

STATEMENT OF ANDREW BOYLE, CO-PRESIDENT, BOYLE TRANSPORTATION, FIRST VICE-CHAIR, AMERICAN TRUCKING ASSOCIATIONS

Mr. BOYLE. Chairman Markey, Ranking Member Ricketts, and members of the subcommittee, thank you for the opportunity to testify.

In addition to serving as first Vice-Chair of the American Trucking Association, I am Co-President of Boyle Transportation, a trucking firm headquartered in Massachusetts. My company has the honor of doing important work delivering life-saving medicine and transporting critical materiel for the U.S. Military.

We employ 200 people, including 160 of the Nation's finest professional truck drivers, and we are recognized as having the No. 1 work environment among smaller fleets in all of the U.S. and Canada in 2020 and 2021. Boyle is a subsidiary of Andlauer Healthcare Group, a highly regarded logistics provider to the North American healthcare industry.

We take tremendous pride in our environmental record. An EPA SmartWay partner since 2008, we have been a SmartWay high performer for five straight years and received EPA's Environmental Merit Award. In 2021, we became the first trucking company in North America to achieve certification for the rigorous ISO 14001 Environmental Management System. Our headquarters is solar-powered.

ATA shares that commitment to sustainability as it represents a diverse industry which includes carriers ranging from enterprise fleets to single truck operations, and which serves every economic sector.

Trucks move 72 percent of America's freight tonnage, a number that will continue to grow. Essentially everything touches a truck. Thanks to collaboration between industry and government, today's clean diesel trucks produce 99 percent lower emissions than those from the 1980's. Sixty trucks today emit what just a single truck emitted in 1988.

This progress is owed to both aggressive innovation and technically achievable national standards. We were aligned with another EPA emissions standard slated to take effect in 2027, which will reduce NOx by yet another 83 percent until EPA recently announced that it was going to reopen that rule. How are manufacturers and fleets meant to comply with regulations that whimsically change with political preference?

EPA also recently decided to create a State patchwork that undermines Federal leadership by approving a waiver for California's so-called Advanced Clean Trucks Rule, which is heavily predicated on the adoption of electric trucks.

While we share the passion for EVs in cars and light duty vehicles, projecting an automotive construct onto trucking industry dynamics is a massive mistake. Let me be clear: if battery electric trucks had adequate range, there was adequate charging infra-

structure, and utilities could deliver the power, we truckers would be delighted, but let me explain our reality.

Today, a clean diesel truck can spend 15 minutes fueling anywhere in the Country and then have a range of about 1,200 miles before fueling again. In contrast, today's long-haul battery electric trucks have a range of about 150 to maybe 330 miles and can take up to 10 hours to charge. For the same 1,200-mile journey, we would go from 15 minutes of fueling a clean diesel truck once to charging today's BEV four to eight times for dozens and dozens of hours. This is assuming there are chargers where you need them.

We would need far more trucks to haul the same amount of freight, and each of those trucks would cost two to three times a comparable diesel truck. Converting the U.S. fleet of Class A trucks to battery electric would require a \$1 trillion investment, which ultimately would flow to consumers.

We welcome the opportunity to provide real-world, factual, and constructive input into the legislative and rulemaking process. We recognize that most people do not understand how the trucking industry works behind the scenes to supply the American public, but we can not allow unrealistic timelines, a State patchwork, and technically unachievable regulations to set trucking up for failure. Remember, we deliver food, medicine, baby formula. Failure is not merely inconvenient; it is catastrophic.

Thank you, and I look forward to answering your questions.

[The prepared statement of Mr. Boyle follows:]



Statement of

Andrew Boyle
First Vice Chair of the American Trucking Associations
and
Co-President, Boyle Transportation

Before the

United States Senate
Committee on Environment and Public Works
Subcommittee on Clean Air, Climate, and Nuclear Safety

Hearing on

“Cleaner Vehicles: Good for Consumers and Public Health”

April 18, 2023

Introduction

Chairman Markey, Ranking Member Ricketts, and Members of the Subcommittee, I appreciate the opportunity to testify before you today on behalf of the American Trucking Associations (ATA) and my company, Boyle Transportation. In addition to my duties as Co-President of Boyle Transportation, I also serve as 1st Vice Chairman on the Board of Directors for the ATA, as a member of the American Transportation Research Institute's (ATRI's) Board of Directors, and as a member of the business advisory committee for the Northwestern University Transportation Center.

ATA is a 90-year-old federation and the largest national trade organization representing the 7.65 million men and women working in trucking-related jobs. ATA is a fifty-state federation that encompasses 34,000 motor carriers and their suppliers, working in all sectors of the industry, from less-than-truckload (LTL) to truckload, refrigerated transport for food and beverage and life sciences, intermodal trucking, auto haulage, and household goods movement. Our members range from the nation's largest motor carriers to mom-and-pop one-truck operations.

Boyle Transportation is a 51-year-old motor carrier providing transportation services to select clients in the bio-pharmaceutical and government/defense sectors. We employ 200 people, including 160 of the nation's finest professional truck drivers, and were recognized as having the #1 work environment among smaller fleets in all of the US and Canada in 2020 and 2021. We have the honor of doing important work – transporting critical materiel to support national defense and delivering life-saving medicine. In December 2020, the first batches of the Pfizer COVID vaccine were shipped on Boyle Transportation trucks.¹ Boyle is a subsidiary of Andlauer Healthcare Group, a highly regarded logistics provider to the Canadian healthcare industry.

Our company has made enormous investments in environmental sustainability. We are the only trucking company in North America to achieve certification for the International Standards Organization's rigorous 14001 Environmental Management System. Boyle has been an Environmental Protection Agency (EPA) SmartWay Partner since 2008, including the last 5 consecutive years as a SmartWay "High Performer." We are a recipient of EPA's Region 1 Environmental Merit Award. Thanks to continual investment in equipment and adoption of best practices, in the last 6 years we have reduced fuel consumption per truck by 20%, reduced CO2 emissions by 14%, and Particulate Matter emissions by more than 50%. Our headquarters is solar powered.

I welcome the opportunity to discuss how the trucking industry has made progress in reducing emissions by deploying cleaner heavy-duty trucks on our nation's highways, as well as the challenges that we face in meeting ambitious goals for achieving further environmental benefits. Boyle Transportation, and the trucking industry as a whole, recognizes the importance of reducing our emissions footprint. I hope that my testimony today will assist the Committee in evaluating the path forward on achievable regulations to improve sustainability in the transportation industry.

The Facts on Trucking's Environmental Progress

The trucking industry has a positive story to tell about our progress in reducing emissions over the past few decades. A new truck today emits 99% fewer particulate matter emissions than one in 1985, and 99% fewer nitrogen oxide (NOx) emissions than one in 1975. 60 trucks today emit what one truck

¹ Smith, J. (2020, December 14). Vaccine Transport Leans on Tight Network of Refrigerated-Truck Operators. *Wall Street Journal*. https://www.wsj.com/articles/vaccine-transport-leans-on-tight-network-of-refrigerated-truck-operators-11607987480?reflink=desktopwebshare_permalink

emitted in 1988. Those cleaner trucks are meeting American's demands to move more freight than ever before. More than 80% of U.S. communities rely *exclusively* on trucking to meet their freight transportation needs, and trucking currently moves more than 70% of the nation's annual freight tonnage.² Over the next decade, trucks will be tasked with moving 2.4 billion more tons of freight than they do today, and trucks will continue to deliver the vast majority of goods to American communities.³ As we meet the needs of our domestic supply chains, we look forward to working with Congress, agencies and stakeholders to continue improving our environmental sustainability.

Boyle Transportation proudly participates in the voluntary EPA SmartWay program, which works with transportation service providers to track, document, and share information about reducing fuel use and freight emissions across supply chains. For the last five years, as a SmartWay "High Performer," we reduced our emissions output to a level 59% lower than that of the average tractor trailer fleet, and we look forward to continuing to achieve emissions reductions through this program.

Since 2004, EPA SmartWay partners in trucking have saved billions of dollars in fuel costs, reduced oil consumption, and eliminated millions of tons of air pollutants. EPA estimates that the program has helped its partners save 357 million barrels of oil since 2004.⁴ If one barrel of oil produces 11 to 12 gallons of diesel fuel,⁵ that means trucking companies participating in the SmartWay program have saved more than 4 billion gallons of fuel—over \$19 billion at current prices—in the last eighteen years. Critically, those fuel savings resulted in massive emissions reductions of 2.7 million short tons of nitrogen oxide (NOx); 112,000 short tons of particulate matter, and 143 million metric tons of CO₂.

Trucking began phasing out harmful sulfur from diesel fuel in 2006, practically eliminating sulfur oxide emissions. ATA also championed two separate EPA and National Highway Traffic Safety Administration (NHTSA) regulations in 2011 and 2016, establishing the first-ever truck engine and vehicle greenhouse gas (GHG) emission and fuel consumption standards—known as Phase 1 and 2, respectively. In total, between 2014 and 2027, the combined Phase 1 and 2 GHG standards stand to cut CO₂ emissions by 1.37 billion metric tons, saving vehicle owners and operators \$220 billion in fuel costs, and reducing oil consumption by up to 2.5 billion barrels of oil over the lifetime of the vehicles sold under the program. As EPA prepares to begin its Phase 3 GHG rulemaking, trucking looks forward to working with the agency to set ambitious, but also achievable, standards.

Compliance Challenges for Interstate Trucking

Aggressive emissions reduction goals are important and necessary. However, our industry's path forward on zero-emission vehicle development requires time for infrastructure to be built out, increased production of clean energy and alternative fuels, and the maturation of a market for next generation vehicles that are affordable for trucking companies of all sizes. Trucking is keenly aware of the costs of new requirements and their impacts on energy supplies and supply chains. Forcing unnecessary demands on the trucking industry such those formulated by the California Air Resources Board (CARB) that recently received EPA waivers for implementation under the Clean Air Act, will harm our supply chains without meaningfully accelerating the deployment of new, clean trucks nationwide.

² *U.S. Census Bureau Commodity Flow Survey*. U.S. Census Bureau, 2017.

³ *Freight Transportation Forecast 2020 to 2031*. American Trucking Associations, 2020.

⁴ *SmartWay Program Successes*, U.S. EPA, Available online at: <https://www.epa.gov/smartway/smartway-program-successes>.

⁵ *Frequently Asked Questions*, U.S. EIA, Available online at: <https://www.eia.gov/tools/faqs/faq.php?id=327&t=10>

While these challenges will be overcome in time, the large-scale substitution of battery electric vehicles will require unprecedented advancements in battery range and capacity, as well as a significant buildout of the national power grid. The path forward for trucking decarbonization requires acknowledgement of market realities that both keep supply chains moving and enable fleets like mine to affordably acquire and install infrastructure. If I want to electrify a battery or hydrogen fuel cell electric fleet, I need infrastructure that is affordable, available, and compatible with the grid, in a way that is timely, reliable, and makes sense for my operation. Unfortunately, that is not the case today.

To the point of needed investments in our power grid to support battery electric vehicles, and specifically heavy-duty trucks, the statistics on the amount of energy that will be consumed following that transition are astounding. A recent ATRI study found that electrification of the entire U.S. vehicle fleet would consume 40.3% of the current electricity demand, yet our aging grid can hardly sustain its current needs.⁶ In California, where rolling blackouts and brownouts are not uncommon, utilities would need to generate an additional 57% beyond their current output to support an electric vehicle fleet.⁷ Beyond the sheer volume of energy production required, installation of charging facilities that fit the demands on commercial trucking is equally vital. Many ATA members who try to install even modest charging infrastructure today are told by electric utilities that it will take years to extend the required service to their facilities, if at all possible.

Whereas the purchase of a car is often driven by personal preference and emotion, buying a truck is an entirely different exercise. A truck is a utilitarian device. Beyond safety, the purchasing decision is predicated on reliability (which we call “uptime”), productivity, and total cost of ownership.

In 15 minutes, a truck driver today can fill his or her truck with enough diesel to travel over 1,200 miles. For battery-electric trucks, a two-hour charge can get you 200 miles, depending on the conditions (range can degrade significantly with cold or hill conditions, or when using HVAC systems). With the advancement of DC fast chargers, this charging time could be cut in half. The next generation of chargers is expensive – roughly \$100,000 each. Even with their installation, it would still require over five hours to achieve the same range you get in 15 minutes today, assuming a truck could even carry that quantity of batteries.

Long-haul trucks require significantly heavier batteries (anywhere from 6,000 to 17,000 lbs.), which leads to reduced payload capacity. When trucks are less productive due to decreased payload capacity, limited mileage range, and downtime for charging, the consequence is that *more trucks and drivers are needed to move the same amount of freight*. Some of our large members running limited-scope BEV operations report the need for a 3:2 and sometimes even 2:1 ratio of battery-powered trucks relative to what their diesel trucks produce. Couple the need for more trucks with the fact that each BEV truck costs 2-3x that of today’s clean diesel truck (a roughly \$300,000 upcharge per unit) and it’s easy to see that the negative economics of BEVs would be felt severely by the trucking industry and in turn shared by shippers and consumers.

While diesel fueling stations allow for throughput of 4-5 trucks per hour, charging stations would service 2-3 trucks *per day*. Every truck parking (not fueling) spot would need a charging station, and we are woefully short of truck parking spots today.

⁶ *Charging Infrastructure Challenges for the U.S. Electric Vehicle Fleet*, American Transportation Research Institute, December 2022. Available online at: <https://truckingresearch.org/2022/12/06/charging-infrastructure-challenges-for-the-u-s-electric-vehicle-fleet/>

⁷ *Ibid.*

Ongoing fuel price volatility, and state-based regulations increasing prices at the pump, continue to cost the industry tens of billions of dollars and make it harder to upgrade equipment to new, cleaner trucks. In 2019, U.S. trucks consumed 45.6 billion gallons of fuel—of which 36.5 billion gallons were diesel.⁸ The trucking industry's fuel bill in 2019 was \$112 billion when prices were \$3.00/gallon. However, diesel prices rose throughout 2022, reaching a high of \$5.81/gallon—90% higher than 2019 average prices. This increase resulted in an annual diesel fuel bill exceeding \$200 billion for the American trucking industry, a nearly \$100 billion yearly increase.⁹

I urge the Subcommittee to be aware of the challenges facing the small- and medium-sized trucking fleets that are the heart of our supply chains in obtaining new, clean trucks. According to statistics from the U.S. Department of Transportation (USDOT), 95.7% of private and for-hire motor carriers operate 10 or fewer trucks and 99.7% operate fewer than 100 trucks.¹⁰ According to a 2022 ATRI survey of the industry, fuel costs (22%), equipment and lease payments (15%), and repair and maintenance costs (9%) account for 46%, or nearly half of the overall operating costs for trucking companies nationwide.¹¹ Surging fuel and truck prices, as well as the deployment of new technologies that are difficult for fleets to maintain, create enormous headwinds that stymie efforts to incentivize fleets to invest in newer, cleaner equipment.

While larger fleets can take advantage of economies of scale as they invest in new equipment, thousands of smaller fleets lack that flexibility. Expensive new engine technologies, historically high diesel prices and interest rates, and the lack of infrastructure to support alternatives such as battery-electric or hydrogen fuel cell vehicles must be considered in evaluating realistic timelines for reducing emissions in freight transportation. Trucking companies support cleaner transportation technologies and fuels that protect the environment, but we are only the consumers who purchase those goods and not the manufacturers. New California requirements that mandate the purchase of specific equipment should take into account whether those trucks are available at the necessary scale to achieve regulatory goals.

Disadvantages of Patchwork State Regulations

Trucking companies traverse state lines multiple times a day, and a strong *national* emissions framework ensures the continuity of our nation's freight networks. ATA strongly advocates for federal emissions regulations to ensure that interstate commerce continues to move. State-based regulations that impact fuel costs or mandate the deployment of particular equipment make it harder for our industry to meet the needs of their customers—your constituents. Federal standards for emissions reduction are necessary to ensure companies transporting freight interstate are not forced to become creative with how, where, and when they purchase and dispatch new equipment to remain compliant.

For this reason, ATA has opposed state-based regulations such as those promulgated by CARB and other jurisdictions while working with federal regulators at the EPA and other agencies to craft harmonized federal alternatives. The recent decision by the EPA to grant California's Clean Air Act waivers to enforce policies that are unworkable for the trucking industry – policies that wholly

⁸ *ATA Economics and Industry Data*. American Trucking Associations, 2022. Available online at: <https://www.trucking.org/economics-and-industry-data>

⁹ ATA Analysis based on EIA fuel pricing data. Available online at: <https://www.eia.gov/>

¹⁰ *ATA Economics and Industry Data*. American Trucking Associations, 2022. Available online at: <https://www.trucking.org/economics-and-industry-data>

¹¹ *An Analysis of the Operational Costs of Trucking: 2022 Update*. American Transportation Research Institute, August 2022.

discounted and marginalized trucking industry participation – will result in unworkable regulations and undermine long-term cooperative efforts to reduce emissions.

California has a unique set of clean air issues due to their particular topography and atmospheric conditions, and for this reason the state should not become the *de facto* template for the next national emissions standards, pollutant criteria, and zero-emissions vehicles sales and purchase requirements. Establishing standards that are not technologically sound or that set unrealistic timelines for the deployment and purchase of new zero-emission trucks will set the industry and country up for failure. Federal standards for these areas need to be technologically and economically achievable, without impeding supply chain operations or business planning for the trucking industry and those who rely on us to deliver their freight.

The Biden Administration’s multiagency *U.S. National Blueprint for Transportation Decarbonization* identifies battery electric technology as a “limited long-term opportunity” in the long-haul segment and points out better-positioned opportunities for hydrogen and sustainable liquid fuels.¹² These alternatives offer advantages in energy density, comparable refueling times with diesel fuel and, in the case of biodiesel and renewable diesel, compatibility with many current internal combustion engine configurations. Despite the aggressive timelines set out by the state of California to mandate battery electric vehicle manufacture and fleet sales, the Administration’s blueprint notes longer, more manageable timelines extending out to 2050.¹³

Allowing California to impose punitive, unachievable mandates that are guaranteed to fail will not help to accelerate deployment of technologies nationwide. State-based standards distort the market for vehicle manufacturers and complicate decisions for purchasers of new heavy-duty trucks. Earlier this year, manufacturers informed California they will not be making certain engines available in the state from 2024 to 2026 due to the state’s ill-conceived emissions standards.¹⁴ EPA should not approve standards that are unachievable or promote their spread to other states. In addition, banning the in-use operation of engines certified to federal standards by requiring California-only emission standards will significantly impact the ability of interstate fleets to manage their national operations.¹⁵

Similarly, aggressive state mandates where compliance relies more on fleets obtaining exemptions than their ability to deploy zero-emission trucks do little to advance this technology. A realistic compliance timeline is needed given the limitations surrounding the capability of zero-emission vehicles combined with the dearth of charging and fueling infrastructure. The business case for a zero-emission truck mandated in California is further impacted if a company needs to operate that vehicle in colder climates or on mountain roads where it will have significantly less range and payload.

Allowing California to proceed under a Clean Air Act waiver will also have a major impact on container cargo moving to and from ports in that state, risking further disruption in facilities that are just now recovering from historic backlogs and challenges with cargo distribution. In December of 2022, 99.87% of visits to the Port of New York/New Jersey were by diesel-powered trucks.¹⁶ At the Port of Los

¹² *The U.S. National Blueprint for Transportation Decarbonization*, page 50, U.S. Department of Transportation, January 2023.

¹³ *Ibid.*

¹⁴ California Air Resources Board, Public Meeting to Consider Proposed Delegation of Authority to the Executive Officer to Consider Proposed Amendments to Mobile Source Regulations, Board Item #23-3-3 Summary (March 23, 2023).

¹⁵ California Air Resources Board, Proposed 15-day Changes to the Proposed Regulation Order Advanced Clean Fleets Regulation High Priority and Federal Fleets Requirements, Section 2015 (r) ICE Vehicle Additions (March 23, 2023).

¹⁶ *PortTruckPass Comprehensive Report*. Port Authority of New York and New Jersey, December 2022.

Angeles, 93% of container moves and 95% of trucks are powered by diesel fuel with virtually all remaining movements powered by natural gas. At the beginning of this year, California prohibited the use of truck engines manufactured prior to 2010, which accounted for 13% of all container moves at the Port of Los Angeles in December.¹⁷ (The figure for New York/New Jersey is even higher at 30.48%.¹⁸)

As CARB seeks to phase out older trucks and mandate only zero-emission trucks at ports by 2035, those drayage trucking companies will have to replace their entire fleets. This mandate is unworkable for an ecosystem of carriers that tend to be small companies operating at low margins, and whose productivity is often victim to unpredictable cargo availability and other commercial complications that reduce their efficient movements to and from ports and inland facilities. These state mandates are unworkable and will drive enormous costs on the trucking industry, risking further supply chain disruption. It's worth noting that despite its intensive regulatory environment, California has one of the oldest truck fleets in the country, with 52% of its trucks not meeting the EPA 2010 emission standard¹⁹.

Federal Solutions for Interstate Emissions Reductions

Allowing states to impose unworkable mandates will not move the needle on large-scale substitution of electric, hydrogen, or alternative fuel models for diesel trucks, or on reducing emissions in the freight transportation sector. Developing achievable federal standards, making new heavy-duty trucks more affordable by repealing the federal excise tax on those vehicles, addressing the unique needs of heavy-duty trucks in the rollout of Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act (IRA) programs and incentives, and allocating IIJA funding toward reducing congestion will all have tangible benefits for environmental sustainability.

Reducing the cost of new, cleaner, or alternative fuel vehicles is the first step to increasing their usage nationwide. While the IRA included purchase incentives for heavy-duty vehicles, those incentives are offset by a century-old tax established to fund our participation in World War I. The antiquated Federal Excise Tax (FET) on heavy-duty trucks and equipment adds an additional 12 percent to the cost of every new truck. To ensure the maximum impact of IRA incentives for clean vehicle purchases, and to encourage the reduction of emissions from trucking and the supply chain, the first important step is removing this onerous tax to immediately make new, clean equipment more affordable. Senators Ben Cardin and Todd Young recently introduced the Modern, Clean, and Safe Trucks Act (S. 694) to repeal this burdensome tax, and we urge the members of this Subcommittee to consider the strong merits of that legislation in the context of broader sustainability goals.

Eliminating the FET will reduce the cost of new technologies by tens of thousands of dollars and is a technology-neutral solution that allows companies to invest in not only battery-electric, but alternative fuel vehicles as well depending on the availability of infrastructure to support the specific technologies. Proposals for hydrogen infrastructure for trucks must ensure that the infrastructure is in place where that technology best fits in supply chains. Where lifecycle emissions can be reduced by deploying renewable diesel and renewable natural gas, those fuel stocks need to be available for trucking.

¹⁷ *Clean Truck Program (CTP) – Gate Move Analysis*. Port of Los Angeles, December 2022. Available online at: <https://kentico.portoflosangeles.org/getmedia/452bad8c-4e16-490f-bab6-155b061866bb/POLA-Monthly-Gate-Move-Analysis> (accessed January 19, 2023).

¹⁸ *PortTruckPass Comprehensive Report*. Port Authority of New York and New Jersey, December 2022.

¹⁹ *Diesel Technology Forum*, dieselforum.org

ATA supports technology-neutral efforts to incentivize the deployment of new, clean trucks. Where Congress has chosen to provide targeted incentives in this area, such as the 45W tax credit for Qualified Commercial Clean Vehicles and the 30C Alternative Fuel Vehicle Refueling Property credit, ATA will work with federal agencies to formulate guidance that will enable industry to maximize the effect of the incentives on emissions reductions.

In the case of initial guidance proposed by the Internal Revenue Service (IRS) on Qualified Commercial Clean Vehicles, ATA recommended changes to extend the credit to vehicles reaping the benefit of maturing technologies that charge vehicles through regenerative braking or solar sources. We hope that the agency will take stakeholder feedback into account as it implements provisions of the IRA. Additionally, because various tax credits and infrastructure improvements affect the underlying economics of trucking and the supply chain, we urge Congress to give the market time to adjust before considering or pursuing additional measures that may drive up the operational costs of trucking.

The availability and price-competitiveness of low-carbon and renewable fuels is also an important area where additional Congressional action could help reduce emissions from trucking. While the IRA increased the tax credit for Sustainable Aviation Fuel (SAF) up to \$1.75 per gallon, the credits for renewable diesel remain at \$1.00 per gallon. As a result, feedstocks for this valuable emissions-reduction tool for trucking are likely to be cannibalized for aviation. Restoring parity for tax credits for renewable diesel – and increasing the tax credit for renewable natural gas, which is used by some trucking companies and is currently eligible for a \$0.50 per gallon tax credit – can have immediate and sustainable environmental benefits.

As technologies for clean vehicles mature and the infrastructure buildout continues for electric and alternative fueled passenger and commercial vehicles, the greatest near-term reduction in emissions must come from dedicating infrastructure funding towards congestion mitigation. Reducing idling hours and time wasted in stop-and-go traffic on our nation's highway bottlenecks will make more efficient use of every gallon of fuel burned, as well as benefit our nation's truck drivers and highway safety. Congress should ensure that highway funding is directed to new²⁰ construction that targets those chokepoints.

Highway congestion adds nearly \$75 billion to the cost of freight transportation each year.²¹ In 2016, truck drivers sat in traffic for nearly 1.2 billion hours, equivalent to more than 425,000 drivers sitting idle for a year.²² This caused the trucking industry to consume an additional 6.87 billion gallons of fuel in 2016, representing approximately 13% of the industry's total fuel consumption, and resulting in 67.3 million metric tons of excess carbon dioxide (CO₂) emissions.²³

Congestion serves as a brake on economic growth and job creation nationwide. A first-world economy cannot survive a developing-world infrastructure system. As such, the federal government has an obligation to ensure that necessary resources are available to address this self-imposed and completely solvable situation. ATA encourages USDOT to prioritize the discretionary program resources made

²⁰ "After Capito, Graves Pledge to Formally Challenge Federal Highways Memo, FHWA Issues Substantially Revised Replacement," U.S. Senate Committee on Environment & Public Works, Press Release, 24 February 2023, Available online at: <https://www.epw.senate.gov/public/index.cfm/2023/2/after-capito-pledge-to-formally-challenge-federal-highways-memo-fhwa-issues-substantially-revised-replacement>.

²¹ *Cost of Congestion to the Trucking Industry: 2018 Update*. American Transportation Research Institute, Oct. 2018.

²² *Ibid.*

²³ *Fixing the 12% Case Study: Atlanta, GA*. American Transportation Research Institute, Feb. 2019.

available by the IIA to address major freight bottlenecks. Furthermore, given the importance of the National Highway System—and especially the Interstate System—to the supply chain, a greater share of federal investment should be directed toward the maintenance and improvement of these highways, which serve as key freight corridors.

Finally, I encourage the U.S. Government to use its purchasing power to encourage fleets that move freight for government agencies to purchase the ultra-low emission vehicles currently on the market and embrace EPA SmartWay's best practices. 47% of Class 8 trucks currently operating nationwide are model year 2010 or older and send far more emissions into the air than today's clean vehicles. The path to long-haul heavy truck electrification depends on technology and infrastructure advancements that will take years to develop. Meanwhile, we can make significant progress in reducing emissions offering a market-oriented "carrot" for implementing best practices for sustainability and deployment of new, clean trucks.

In Conclusion

Thank you for the opportunity to testify before you today on the progress being made by the trucking industry to reduce emissions in recent decades. I am grateful for the opportunity to share my company's unique sustainability success story and welcome the chance to discuss workable solutions to the environmental challenges we face.

On behalf of the American Trucking Associations and the 7.65 million people in trucking-related jobs who power our nation's supply chains and keep the wheels of the economy turning, we look forward to working with the Subcommittee and Congressional leaders to support legislation that will help us meet ambitious energy and emissions goals. Thank you.

**Senate Committee on Environment and Public Works
Subcommittee on Clean Air, Climate, and Nuclear Safety
Hearing Entitled, “Cleaner Vehicles: Good for Consumers and Public Health”
April 18, 2023
Questions for the Record for Andrew Boyle**

Ex-Officio Chairman Carper:

1. Please provide an example of where you believe there is common ground among all witnesses who testified before the Committee for this hearing.

Chairman Carper, thank you for your question. I believe that all witnesses share the belief that reducing emissions across the transportation sector is an important and worthwhile endeavor. Further, I believe all witnesses believe there is an important role for ambitious but achievable goals for federal emissions standards that take into account the unique demands of the passenger, light-duty, and heavy-duty commercial vehicles marketplaces.

Programs like the Diesel Emissions Reduction Act (DERA), which you championed, as well as the repeal of the Federal Excise Tax, are two areas where trucking looks forward to working with Congress to achieve those valuable emissions reductions.

Senator Kelly:

1. Mr. Boyle, in your testimony you discuss how mitigating congestion and making highways more efficient can play a role in reducing emissions. I have studied this issue and worked with my colleague on the Committee, Sen. Lummis, to introduce legislation to fund construction of safe truck parking nationwide. Can you speak to the environmental impacts of this effort?

Senator Kelly, thank you for your question and for your leadership on the Truck Parking Safety Improvement Act. There is currently one truck parking spot for every eleven trucks on the road, and drivers spend up to an hour every day looking for a safe space to park. In many cases, drivers are forced to park in unsafe areas or locations without infrastructure to support their basic needs such as fuel, food, restrooms and showers.

Lack of available safe truck parking leads to less efficient use of heavy-duty trucks and equipment, with more time idling in residential and sometimes unsafe areas, and less time spent moving freight to its final destination. Building out a nationwide network of safer truck parking will not only ensure more dignified treatment of our driver workforce but will also help to maximize the efficient use of trucks and trailers for that daily hour that is currently wasted searching for parking.

2. Mr. Boyle, from your testimony, I understand that you work closely with government agencies to move freight. Is there a role that federal agencies can play in reducing the emissions impact of the transportation sector?

Boyle Transportation does work closely with federal agencies and, as I mention in my written statement, I believe there is an important role for those agencies in reducing emissions. Using the purchasing power of the federal government to encourage fleets moving agency freight to deploy ultra-low emission vehicles and embrace SmartWay voluntary best practices would lead to significant emissions reductions.

Approximately 47% of Class 8 trucks currently operating nationwide are model year 2010 or older, and upgrading those trucks to new, clean diesels will provide important environmental benefits as technologies mature for zero-emission vehicles and the infrastructure to support those trucks is built out. Weighting sustainability efforts in procurement for government agencies such as the Department of Defense, General Services Administration, and United States Postal Services would be a valuable tool in incentivizing deployment of modern, clean, safe vehicles.

Ranking Member Ricketts:

1. Mr. Boyle, will you elaborate on the logistics implications of utilizing electric vehicles in your fleet, especially as it pertains to the transport of hazardous materials?

Ranking Member Ricketts, thank you for this question. One of the challenges for utilizing electric vehicles to move hazardous materials, or any freight, is the shorter length of haul and long charging cycles for truck models currently available on the marketplace. It would take substantially longer to move sensitive freight – including medicine and military materiel – long distances due to the charging issues, whereas a new, clean diesel truck can travel up to 1,200 miles after fueling for 15 minutes. Sensitive freight movements using current electric vehicle technologies would be parked for long times, increasing its risk and exposure towards potential criminal activity.

Also, it is ironic that lithium batteries are classified as hazardous materials when hauled and subject to restrictions, such as prohibited from traveling through the Eisenhower Tunnel, while electric vehicles are not subject to these same restrictions. Were electric vehicles subject to similar restrictions, it would complicate routing and make it more difficult to manage fleet equipment.

2. Mr. Boyle, your company also supports our government and defense sectors. What concerns do you have with transporting these assets on an electric fleet?

The challenges of moving government and defense freight on electric vehicles are similar to the challenges of moving any sensitive goods on new technology. As I mentioned above, the shorter range and longer "refueling" times for electric vehicles will slow the transit of those goods.

Additionally, the infrastructure is in place nationwide to fuel and maintain diesel trucks, which ensures reliable service for the agency customer even in the unfortunate (but all too common) instance when equipment needs last-minute maintenance or diversion over less-direct routing.

Finally, the biggest concern with transitioning to an electric fleet to move assets of any kind, for any customer, is that electric trucks and the necessary supporting infrastructure are not yet in place or affordable for my company to consider such a shift in our business.

3. Is it feasible for Boyle Trucking to replace its entire fleet with an electric fleet that is majority manufactured in North America?

At this time, it is not feasible for Boyle Trucking to replace its entire fleet with an electric fleet due to the price of the vehicles, lack of overall power-unit availability in the marketplace, lack of supporting infrastructure, and the range constraints that electric vehicles would place on our network. The timeline for development and capabilities of fuel cell electric vehicles as an alternative to battery electric vehicles is a further unknown.

I do believe that the key truck manufacturer partners that serve our industry are working to develop the North American manufacturing capacity to make that shift possible in the longer term. However, as I noted in my written statement and during the hearing, there remain serious questions about where the raw materials that go into manufacturing key components such as batteries will come from in order to enable the full electrification of America's trucking fleets in the long-term.

4. Under its proposed Phase 3 Greenhouse Gas Emission standards for trucks, EPA believes financial incentives under the IRA for both charging infrastructure and zero-emission truck purchases will dramatically accelerate fleets' buying zero emission trucks. On behalf of ATA's fleet members, many of whom rent or lease their vehicles to small businesses and everyday Nebraskans, do you believe this a valid assumption for EPA to take?

The cost of zero-emission trucks and charging stations is only one small part of the business case for choosing to buy, or not to buy, those vehicles. Range limitations, charging downtime for those vehicles, a lack of maintenance technicians to keep those vehicles on

the road are other major hurdles that must be addressed before their widespread deployment. Also, even if those challenges were already solved, our nation's electric grid must be substantially upgraded, and a significant amount of electricity production increased in order to meet the demands of an electrified national trucking fleet.

As I stated in both my written testimony and during the hearing, the best way to reduce emissions from trucking is to repeal the federal excise tax on heavy duty trucks. This will reduce the costs of both new, clean diesel trucks as well as ensure that IRA incentives for zero-emission vehicles are not undermined by a century-old 12% tax on those substantially more expensive trucks. Trucking has seen a roughly 80% decrease in emission between newer trucks and 2010 models, and the most direct and cost-efficient route to reducing national emissions is to encourage the retirement of those models in favor of existing, available power units.

Senator MARKEY. Thank you, Mr. Boyle, very much.

Now, we will turn to questions from our panel. I will begin by just pointing out that when I served in the House of Representatives, I authored the fuel economy language in the 2007 Energy Independence and Security Act that kickstarted the new race to the top for vehicle efficiency, and that legislation made it clear that we must set the maximum feasible standard for fuel economy.

The EPA standards are no different. They must “reflect the greatest degree of emissions reduction achievable through available technology.” Well, in the Inflation Reduction Act, the Bipartisan Infrastructure Law, and the CHIPS and Science Act, Congress invested more than \$135 billion to make clean vehicle technology more available than ever.

To each of the witnesses, do you believe that investments from these bills are making clean vehicles more affordable and available? We will begin with you, Ms. Harris, and Mr. Harto, then you, Mr. Boyle.

Ms. HARRIS. Thank you so much for your question, Senator.

I think the short answer is yes. We are seeing that the upfront prices of electric vehicles costs are reducing, and that is in large part due to the Inflation Reduction Act and the tax incentives passed by this body, but additionally, we know even today that the total cost of ownership of electric vehicles is still cheaper than a comparable gasoline car. We are seeing an increase of desire for these vehicles from the American people, as well.

Senator MARKEY. Meaning that over the life expectancy of the vehicle, you spend so much less on electricity than you do on oil?

Ms. HARRIS. Yes, and the maintenance costs of the vehicles are lower, as well.

Senator MARKEY. Yes. Mr. Harto?

Mr. HARTO. Yes. We do believe that these policies are helping to accelerate and bring more EVs to consumers cheaper. The more automakers do something, the better they get at it. Learning by doing and economies of scale are two of the biggest drivers of cost declines in any industry. The more clean vehicles automakers deliver, the cheaper they will be able to offer them to consumers.

Senator MARKEY. Let me go to you, Mr. Boyle. What incentives are most helpful to the trucking industry in the legislation thus far to increase the ambition to move to clean vehicles?

Mr. BOYLE. Thus far, the adoption of BEVs, so in a heavy-duty truck, the upcharge is roughly \$300,000. The incentives barely cover the Federal excise tax, which is an issue we would like to bring up, because I know some of your colleagues have been advocating for us. A huge impediment to buying newer, cleaner trucks, even today's trucks, is the Federal excise tax that was installed more than 100 years ago to finance World War I.

A big issue when we look at the emissions in aggregate right now is not so much that today's trucks are not clean enough, it is just that of the fleet on the road, not enough are today's trucks. This is one lever we have to kind of make it more affordable for fleets and operators to buy today's clean trucks.

Senator MARKEY. Yes. My father was a truck driver, so I grew up with a truck driver as my father, so I am very conscious of this profession and the need to have these vehicles be able to operate.

Mr. Harto, would the investments which are being made in EV charging help to deal with the range anxiety that people have had in purchasing an EV in the past?

Mr. HARTO. Absolutely. Charging infrastructure is one of the biggest barriers to EV adoption in the U.S., and the Bipartisan Infrastructure Law provides significant investments to especially roll out those chargers in areas where the free market is lagging, States like Senator Ricketts' Nebraska, as well as low-income areas of the Country.

It is really targeted at filling the gaps where the market is missing to help consumers feel confident that they can buy an electric vehicle.

Senator MARKEY. Ms. Harris, how quickly is this transition occurring in terms of consumers' demand and the purchases of electric vehicles, especially the light duty, the SUVs?

Ms. HARRIS. We are seeing a great increase in the interest in electric vehicles. Last year, electric vehicle sales were about 4.5 percent over the course of the year, and in 2021, they were about 4.5 percent. In 2022, that rose to about seven percent over time. We have even seen that in December 2022, that was almost up to nine or 10 percent sales, as well.

So there is a continuous increase in interest in these vehicles, and we are seeing that demand increasing annually.

Senator MARKEY. Beautiful. Thank you. Senator Ricketts?

Senator RICKETTS. I will yield to Senator Lummis.

Senator LUMMIS. Thank you very much, Senator Ricketts, and thank you, Mr. Chairman.

Ms. Harris, do you believe it is appropriate to analyze only the tailpipe when calculating greenhouse gas emissions?

Ms. HARRIS. Thank you so much for your question, Senator. I believe that electric vehicles and the tailpipe emissions from the transportation sector are a major source of toxic pollutions in the United States.

Senator LUMMIS. OK, so what about the fact that method misses significant emissions generated through the extraction of rare earth minerals in foreign countries that are needed to create EV batteries?

Ms. HARRIS. There have been many studies that have shown that electric vehicles today from well to wheel are still cleaner than compared to a gasoline vehicle.

Senator LUMMIS. However, you have not analyzed the need for rare earth minerals and the mining, the significant mining that has to occur. Can you confirm that lithium, cobalt, manganese, nickel, and graphite are all critical to the manufacturing of electric vehicle batteries?

Ms. HARRIS. Many of the batteries that are currently made today for electric vehicles do require those minerals.

Senator LUMMIS. Do you know which country is the third-largest producer of lithium and controls 60 percent of global battery-grade lithium refining capacity?

Ms. HARRIS. I do not have that number in front of me today.

Senator LUMMIS. Well, it is China. Do you know which country is responsible for over 50 percent of cobalt exports?

Ms. HARRIS. I do not have that number in front of me today.

Senator LUMMIS. It is the Democratic Republic of the Congo. Do you know which country is responsible for nearly 75 percent of global exports of manganese?

Ms. HARRIS. I do not have that number in front of me today.

Senator LUMMIS. It is China. Do you know which country is responsible for the most exports of nickel?

Ms. HARRIS. I do not have that number in front of me today.

Senator LUMMIS. That would be Indonesia. Do you know which country is responsible for nearly half of the global graphite exports?

Ms. HARRIS. I do not have that number in front of me today.

Senator LUMMIS. That is also China. Do any of these countries have anywhere near the stringent environmental regulations the United States has?

Ms. HARRIS. I cannot speak to that today.

Senator LUMMIS. You do not know? You do not know whether these countries are mining in a more environmentally friendly way than the United States?

Ms. HARRIS. Oh, I am sorry. I misunderstood the question. Could you please repeat it?

Senator LUMMIS. Do any of these countries have anywhere near the stringent environmental regulations that the United States has?

Ms. HARRIS. My apologies. Not to my awareness.

Senator LUMMIS. If climate change really is a worldwide problem, how does shifting the responsibility of mineral extraction to these countries help us reduce worldwide emissions?

Ms. HARRIS. Thank you so much for the question. I will say that there are many investments and incentives that are happening here in the United States to bring the supply chain to the United States.

Senator LUMMIS. I have a rare earth mine in my State that has been trying to open for over 10 years and still does not have the environmental permitting to open. There is no way that the standards and the materials needed to produce and manufacture in the United States can happen in 10 years.

To ramp up the supply even in foreign countries that have far lower environmental standards, not to mention human labor standards, this is not possible to do. It is going to take four to six times more product, and then the mining and milling of that product over a 10-year period to meet the regulatory standards that the EPA is advocating for.

It is going to raise greenhouse gases all over the world, including in China, Indonesia, the Democratic Republic of the Congo. It is going to create child labor and human labor issues that are deplorable. We are doing that all so we can provide a vehicle that costs \$65,000 to the American consumer, and that if you are in an accident, you have to replace the whole vehicle, because the battery can not be damaged? To me, there is really nothing about this idea that is reflective of global reality.

Mr. Chairman, I would like to enter into the record this article about the gamble on critical minerals that is being undertaken with regard to this proposed EPA regulation.

Senator MARKEY. Without objection, so ordered.

[The referenced information follows:]

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BLOG

INFRASTRUCTURE AND SUPPLY CHAINS WON'T HOLD UP EPA'S PROPOSED LIGHT AND MEDIUM-DUTY VEHICLE STANDARDS

APRIL 26, 2023 | By: Stephanie Searle, Drew Kodjak, and Peter Slowik

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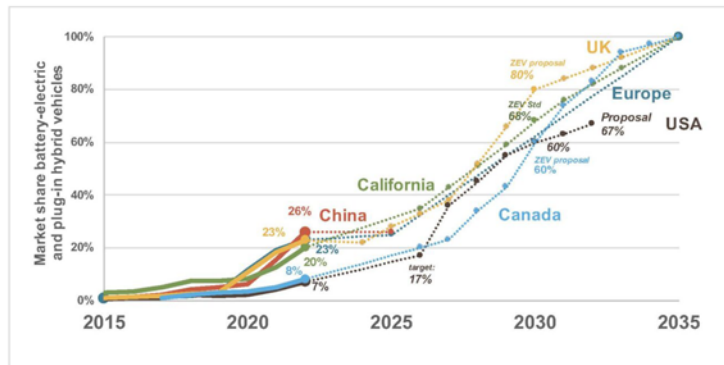
[Vehicle efficiency](#)

The U.S. Environmental Protection Agency's (EPA) light and medium-duty vehicle proposal builds upon important climate legislation enacted in last year's Inflation Reduction Act (IRA) and in the 2021 Infrastructure Investment and Jobs Act (IIJA). EPA expects the regulation, proposed on April 12, 2023, to lead to a 67% electric vehicle (EV) sales share in 2032 for light-duty vehicles such as cars, SUVs, and passenger pick-up trucks and 46% for medium-duty vehicles including vans and larger pick-ups.

This proposal is a critical complement to fiscal incentives. It establishes a clearly defined timeline for automakers to ramp up EV production and sales and allows other supporting businesses – from automotive suppliers and battery manufacturers to charging infrastructure companies and electric utilities – to invest with confidence. And with wait times for EV purchases hovering around 6 months, [consumers are clearly demanding](#) more and faster EV production.

When it's finalized and implemented, EPA's regulation will put the United States on par with other leading countries and jurisdictions in terms of growing EV sales. In 2022, 7% of new U.S. light-duty vehicle sales were electric, trailing California (20%), the European Union (23%), the United Kingdom (23%) and China (28%). EPA's proposal will help the U.S. catch up to global leaders in terms of EV targets as early as in 2027.

This graph shows historical EV sales shares (solid lines) and regulatory targets (dotted lines) for light-duty vehicles. Not shown, the 46% EV sales share EPA projects for medium-duty vehicles in 2032 is more ambitious than the [40% required for this category](#) in California's Advanced Clean Trucks (ACT) rule, a reflection of how much the market and technology has advanced since the ACT was passed in 2020.



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Figure: Historical (solid lines) and regulatory targets (dotted lines) for EVs in different jurisdictions. (Note: Data for China and the United States is from Marklines. Data for Europe is from the European Environmental Agency (EEA) and Dataforce. Data for China and Europe only includes passenger cars, while data for the United States also includes light trucks.)

These targets line up with announcements from auto manufacturers. [Ford](#), [GM](#), [Mercedes-Benz](#), [Audi](#), and others have committed to selling 100% EVs globally or in leading markets by 2035. [Stellantis](#) (which includes Chrysler) and [Volkswagen](#) have set more ambitious goals of 100% and 70%, respectively, for their European sales in 2030 compared to the 50% EV sales target they set for the U.S. That shows automakers can deliver more to the U.S. market – if we put the right policies in place.

Critically, major automakers are collectively investing over \$1.2 trillion in EVs globally. EPA's proposed rule will help bring a significant share of that investment to the United States.

EPA's proposal and goals from automakers are realistic and possible because of technological advancements in EVs and batteries, their underlying economics, and impactful policy incentives. We already know that [consumers will save money](#) over the first ownership period of an electric passenger car, thanks to lower fueling and maintenance costs. In terms of vehicle cost – and by extension price at the dealership – we expect [light-duty EV manufacturing costs](#) to fall below those of their gasoline counterparts for cars, crossovers, SUVs, and pick-ups starting as soon as next year for electric cars with 150-mile range and for all electric passenger vehicles with ranges up to 400 miles by 2030 except for pickups (2033), even without incentives.

The IRA will boost consumer savings even more. Although the U.S. Treasury Department's new guidance restricts the \$3,750-7,500 tax credit to 14 models, compared to 91 EV models available on the market, [those 14 account](#) for most EV sales. [Bloomberg New Energy Finance](#) reported that 65% of all U.S. EV sales would qualify for at least part of the tax credit based on 2022 sales data.

Admittedly, there is significant uncertainty as to the number of EV that will be eligible for all or part of the \$7,500 tax credits over the next decade. Accounting for this uncertainty, we forecast that [new EV sales could reach 56-67%](#) in the U.S. by 2032 based on consumer demand supported by EV tax credits and state adoption of supporting policies. This means that the IRA could get us most – or all – of the way to the EPA's proposed EV sales target that matches the high end of our forecast as 67%.

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Since there are more than enough minerals available for a global transition to EVs, the challenge is how to scale up investments into mining and battery production within this decade. With the IRA's Advanced Manufacturing Production Tax Credit and the domestic content provisions in the Clean Vehicle Tax Credit, the U.S. directly incentivizes mining, recycling, and battery production on U.S. soil, and further supports establishing resilient material supply chains from friendly countries. The manufacturing subsidy of \$45/kWh cuts about one third of total battery costs ([global average of \\$151 in 2022](#)), making battery production in the U.S. even cheaper than in China.

This support showed an immediate effect. In response to the IRA, we saw a significant uptick by more than [one-third in announced plans](#) for battery production facilities, catching up with [Europe](#). Longer-term forecasts now indicate U.S. battery production capacity at [1 TWh by 2030](#), within striking distance of forecasted battery demand of 1.2 TWh taking the proposed EPA standards into [account](#).

So why are EPA's standards necessary if the IRA might already be enough to deliver significant EV growth?

Because the IRA is a supporting mechanism, not a roadmap. We've seen that unless they're held to meaningful standards, automakers dial back on their commitments to EVs. For example, GM committed to deliver [23 EV models in 2023](#). That number is now down to eight.

More than that, clear targets and sustained commitments will help build out the charging infrastructure needed to support accelerated electrification. Other countries have met that challenge, and so can we. Norway hit nearly [80% EV sales in 2022](#) with [one public charger for every 26 EVs](#). Significant resources are already being dedicated to charging, including the [\\$7.5 billion allocation from the IIJA](#) as well as several billions of dollars in [power utility](#) and private sector investment. For example, [British Petroleum announced plans](#) to invest \$1 billion in EV charging in the U.S. by 2030. Automakers are investing too – [GM, working with its dealers](#), aims to install up to 40,000 public charging stations across the U.S. and Canada. Globally, [Bloomberg New Energy Finance](#) expects \$100 billion to be spent to grow charging infrastructure in the next 3 years alone.

Lastly, EPA's proposal is what we need to get closer to meeting our climate goals. In an earlier analysis, we found that [nearly 70% EV sales share](#) would be needed by 2030

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(along with improvements in gasoline vehicle efficiency) to reach the goals we set in the Paris Climate Agreement. [EPA's proposal moves us close to that.](#)

Finalizing the regulation would address climate change, respond to EV market demand, and enhance U.S. global competitiveness while establishing the EV roadmap that automakers, suppliers, charging companies, and utilities need to make needed investments with confidence. That's why the EPA should move ahead as quickly as it can to finalize and implement its proposal.

Related Content

Press release	White paper	White paper	Blog
EPA should work to quickly finalize multipollutant rule for light and medium-duty vehicles	Analyzing the impact of the Inflation Reduction Act on electric vehicle uptake in the United States	Assessment of light-duty electric vehicle costs and consumer benefits in the United States in the 2022–2035 time frame	Aligning the U.S. greenhouse gas standard for cars and light trucks with the Paris Climate Agreement
APRIL 12, 2023	JANUARY 31, 2023	OCTOBER 18, 2022	DECEMBER 19, 2022

Senator LUMMIS. Thank you. I yield back.

Senator MARKEY. OK. Senator Cramer is recognized.

Senator CRAMER. Thank you, Mr. Chairman. Thank you, witnesses.

I have to say, I have taken more notes while I was listening to Senator Lummis than I came with. A couple things that struck me right away, as well as listening to your earlier testimony, Mr. Boyle. We acknowledge that they are heavier. We have acknowledged they are more expensive. Maybe the incentives do not even cover the excise tax.

What does it cost to insure a vehicle like a large truck that has these extra costs and weights and an infrastructure, frankly, not designed for 5,000 more pounds per axle, and those kinds of things?

Mr. BOYLE. Yes. It is hard to tell because we are so, the consumer-facing EV product is so much further ahead, right? We are talking about a very heavy duty, under high stress, corrosive environment. Just so we are clear on the scale of the issue, each electric vehicle battery for a heavy-duty truck weighs 8,000 pounds. You would need at least two of them. We are talking the weight of four or five cars.

My friends and peers in the industry nationwide who have tried to make efforts to put in, say, hey, I am going to convert a dozen forklifts to electric, or I want to tee up a facility for 30 electric trucks, there is no power. The utilities come back, the cities come back and say, is this some kind of joke?

One friend tried to put in Illinois a facility, teed up for 30 trucks for electrification. The city came back and said, this is some kind of joke. You are asking for more draw than the entire city requires.

Just to give you an idea, 30, 50 trucks, that is like a five-or six-megawatt application. The factory that makes the trucks is a two-megawatt factory.

We are playing checkers right now. We would be delighted to have more choices. If the power and infrastructure is not available, it is not even a consideration for trucking, yet California wants to make it effective next January as the only choice. No diesel trucks, no OEM is going to be compliant with California Carbon Standard for a diesel electric truck starting in January. They will have product due to credits and so forth, but none is going to be technically compliant.

What are we talking about here? We are trying to serve the Country and supply commodities that are essential to everyday life, so before any of the, this is not a choice, we have the cart before the horse right now.

Senator CRAMER. Well, and the fight over the infrastructure piece is not a small matter, either. When you start talking about all these socialized costs for a grid that covers every inch and socializes the cost of every little generator and every street corner, another issue I am not suggesting we get into right now.

But building even more on what Senator Lummis was talking about with regard to the supply chain, the Congo, Indonesia, China, and the human rights violations and the work force challenges, certainly standards that do not meet ours, to me, those are

of greater importance than some of the other issues we are trying to solve.

Here is the other irony. She has an opportunity in her own State that is not being done. We know of two critical minerals mines that have been shut down before they even had an EA in this Country, by this Administration, this year, one in Minnesota, Twin Metals, and one in Alaska, Pebble Mine. You are right, the cart is before the horse. Let us build the horse and find the supply chain that can produce some of these things before we start incentivizing things.

The other thing I would bring up, unlike Senator Lummis, I do not come from a tropical environment like Wyoming. I come from the arctic State of North Dakota.

[Laughter.]

Senator CRAMER. Or Nebraska, which is balmy by comparison. The performance in cold weather is not just unproven, it is proven to be horrible. I just can not imagine pushing this standard on North Dakota.

Mr. BOYLE. That is right, sir. The battery degrades in cold conditions, up to about a third. That range I talked about, 180 to 150 to 330, it is degraded by 30 percent.

Senator CRAMER. Is range fairly important in the trucking industry?

Mr. BOYLE. If you want to talk about range anxiety, we truckers would need therapy.

Senator CRAMER. I bet. With that, my point is made. I appreciate you all being here, and I yield. Thank you.

Senator MARKEY. Senator Ricketts?

Senator RICKETTS. Thank you, Mr. Chairman.

Mr. Boyle, you talked about the trucking industry. Talk a little bit about, the trucks are heavier, you said, like 8,000 pounds for a battery. Does that mean that you can not haul as much, your payload is reduced? Is that correct?

Mr. BOYLE. That is correct, which means more trucks to haul the same amount of freight.

Senator RICKETTS. You are going to need more trucks on the road. Does that mean that consumers are going to have to put up with more trucks on the road as they are driving around, right, because there would be more traffic?

Mr. BOYLE. Certainly.

Senator RICKETTS. Is there a shortage of truck drivers in your industry today?

Mr. BOYLE. We estimate about roughly 70,000, 72,000 short currently.

Senator RICKETTS. However, you would need more truck drivers if you are going to need more trucks, is that fair?

Mr. BOYLE. Yes, sir.

Senator RICKETTS. OK, so talk to me about what your experience is from your industry about some of your friends you have talked about doing it, something along those lines of more trucks, how many more trucks are we talking?

Mr. BOYLE. Yes. We have members of ATA who have limited scope operations where they are testing BEVs. What they have found is that they need about a three-to-two or occasionally two-

to-one ratio of trucks, meaning for every route and mission that one truck would do in an internal combustion, reliability was high, they now have to use two BEVs due to charging downtime, reliability, et cetera.

Senator RICKETTS. Is it fair to say that is more expensive?

Mr. BOYLE. Certainly.

Senator RICKETTS. One of the things, also, that you were talking about is, if you have this cost, and also the tractor trailers themselves, I was told by somebody in the industry that a regular tractor trailer diesel runs \$180,000. These are about \$500,000. Is that ballpark correct?

Mr. BOYLE. Yes. Yes, so for the tractor part of a tractor trailer, about \$180,000 to \$200,000 for a sleeper truck and then, in comparison to the \$450,000 thousand price point for a battery.

Senator RICKETTS. I just want to reemphasize something you said in your testimony. Who, ultimately, is going to pay for this, I think you said, a trillion dollars in additional costs? Who is going to pay for that?

Mr. BOYLE. Ultimately, it flows to the consumer.

Senator RICKETTS. The American consumer will end up paying that.

Mr. BOYLE. Yes.

Senator RICKETTS. Now, the American consumer is going to have to foot the bill for all this so forth, and I think that there was an ATRI study that showed that the trucking industry used about 10 percent of our electric power generation?

Mr. BOYLE. I think it is actually more, sir. It is closer to 14 percent, so we would be putting an incremental load of 14 percent on the grid.

Senator RICKETTS. OK. Mr. Harto, can you help me? We have this one study that talked about, trucks would need 14 percent more, is that 14 percent more, or 14 percent overall power generation, Mr. Boyle?

Mr. BOYLE. Effectively, it means we need 14 percent more power generation, incremental.

Senator RICKETTS. Got it. I think the electric vehicles, if you electrify the entire fleet, it is 40 percent of our current power capacity generation. That is a study out there right now.

Are you aware of, are there studies where somebody has put pencil to paper to see how much more we would have to increase our power generation that has different numbers than what we just talked about here?

Mr. HARTO. Yes. The United States Department of Energy (USDOE) research labs, I forget which ones, have done this type of analysis. I know at least for the light duty vehicle sector, we are looking at increased growth in generation demand of about one percent per year, which is well within what the electricity industry has done in the past, when we deployed AC.

Senator RICKETTS. Really, Mr. Harto, one percent per year, when Gavin Newsom last year announced within the same week that he wanted to ban the sale of all internal combustion engines in California by 2035, and then told people with electric vehicles, you can not charge them in the afternoon, because the grid can not handle it?

Mr. HARTO. Yes.

Senator RICKETTS. Didn't that seem like a disconnect to you? It does not seem like a disconnect to you?

Mr. HARTO. It is about one percent per year in overall generation need. As well, utilities have a lot of tools to move around when EVs charge. Time of use rates, managed charging, eventually we will have vehicle-to-grid technology where EVs, when they are not being used, can push power back to the grid and help get through those peak periods in the late afternoon, when everybody is running their AC, everybody is coming home and cooking dinner, and demand is very high.

Senator RICKETTS. When you say manage, when you say managing your charging, you are talking about like Gavin Newsom is talking about management, do not charge it in the afternoon. Is that what you are saying?

Mr. HARTO. You can plug in, you can have your car sitting in your driveway, plugged in, and your utility can just switch it on and off for a few minutes, for a few hours. Typically, you only need it charging for a couple hours a day.

Senator RICKETTS. If they can do that, why isn't California doing that right now? Why would he have to tell people, do not charge your cars?

Mr. HARTO. It still takes a little bit. We are in the first inning of the EV transition. A lot of this stuff is going to get a lot better as we scale up.

Senator RICKETTS. Eventually. OK, thank you Mr. Harto. Thank you, Mr. Chairman.

Senator MARKEY. Thank you, Senator Ricketts. If Senator Merkley is ready, or I could go for another round and then recognize you. Are you ready to go now? OK.

Let me come back to you, Mr. Harto. Is it not true that the Inflation Reduction Act protects against the use of minerals from countries of concern that make vehicles ineligible for the tax credit if they are using minerals from China, from Russia, from countries of concern?

Mr. HARTO. Absolutely. The Inflation Reduction Act puts strong incentives in place for automakers to realign their supply chains and secure them away from countries of concern.

Senator MARKEY. Yes. Countries of concern is just another way of saying, countries we are not really confident of having the correct environmental standards, or that we can trust them as a national strategic partner for a transition as important as this. Is that correct?

Mr. HARTO. Yes, that is correct.

Senator MARKEY. Right now, we are hearing some complaints from some automakers that the new IRS rules are not going to allow their vehicles to qualify because they are importing too many materials from China. Is that correct?

Mr. HARTO. Yes, that is correct, but many of those automakers are rapidly moving to realign their supply chains in order to qualify for these very strong incentives.

Senator MARKEY. In other words, you heard Senator Lummis go down this whole list of concerns, which is obviously the whole point

of the CHIPS Act, the whole point of the Inflation Reduction Act, the whole point of the Infrastructure Bill.

It is just to say to China, we do not need your materials anymore, and to Russia, we do not need your oil any more than we need your caviar, and to Saudi Arabia, we do not need your oil any more than we need your sand. We are fine; you can keep it. We are moving in a new direction.

That is really what those three big bills are all about. Is it not true, Mr. Harto, that is the goal?

Mr. HARTO. Yes, that is correct.

Senator MARKEY. Yes, we are going to be in a little transition period right now, obviously, where there will be a little bit of a grace period for some of these materials to be used, but after that, we are on to a whole new era where we are not only using materials from countries that we have close partnerships with, but also that we are going to make in America. Go through that, Mr. Harto, a little bit.

Mr. HARTO. Yes. Large portions of the world's reserves of critical minerals are actually from countries like Canada, Australia, and Chile, with which we have strong trade partnerships with. Again, automakers are working hard to realign their supply chains to meet these standards.

Senator MARKEY. Are they making that transition?

Mr. HARTO. The massive investments that they are putting into this transition to electric vehicles say that they are.

Senator MARKEY. They say that they are.

Ms. Harris, there are some complaints that this is too ambitious, but you are saying the real world says no, there is a big appetite for these vehicles.

Ms. HARRIS. Yes, that is correct. To Mr. Harto's point, automakers have already announced over \$210 billion of investments here in the United States to help with that transition and, as you mentioned, help bring that supply chain here to the United States, which will continue to increase the benefits to the economy and to drivers.

Senator MARKEY. Yes. I had this problem, actually, back in the 1990's. I was chairman over Telecommunications, and unfortunately, Alexander Graham Bell would have still recognized our phone system, those black rotary dial phones, or a cell phone that was the size of a brick that Gordon Gekko was using in Wall Street. How can we move to the future?

So, my bill, that I was the principal Democratic author of in 1996, said, break up all these monopolies. They are stultifying technological growth, and by 2000, four years after the bill passed, we have a broadband revolution. We had a dot com bubble, but everyone had broadband except for the most rural parts of the Country and the poorest people in our Country. It had just been held up.

We heard from the auto industry for so many years, we can not do this, you do not know how hard it is, if you knew what you were asking for, you would not even raise the subject. Well, now, of course, finally, the auto industry is accepting the future. Now, they let Tesla get a huge lead on them by maintaining their denial that

you could do it. The battery technology, all of these new technologies, they are all happening and improving very rapidly.

The interesting thing about the 1996 Telecommunications Act is that it created a broadband revolution. What is the electricity revolution? The electricity revolution is a broadband revolution. You can manage the electricity coming in off the ocean, off the prairies, off of roofs. You can manage the electricity inside of people's homes and buildings, and you can manage automobiles and trucks, feeding electricity back into the home or into the grid.

All of that is now possible because of the broadband revolution, and this revolution is going to create all new revolutions in battery storage technologies, in the ability for us to be able to imagine where our electricity comes from, or what kind of vehicles we have.

There has always been really, very strong opposition to these kinds of technological revolutions, and I understand that, because it is just part of looking at the world in a rearview mirror. We have to be sensitive to industries that are going to be impacted. The legislation, the regulations are trying to do that, and I am sure there are some accommodations that can be made.

Nonetheless, because of the imperative of us to back out imported oil, national security issue, to reduce greenhouse gases going up, national security issue, we really do not have a choice. This bill is saying to China, to Russia, to other countries, we are not going to need your minerals anymore. We are not going to need your parts anymore. I think that is a big part of what the message is that is being sent to the private sector, and it is largely responding.

We are going to have to make some adjustments, obviously, but I still think that we have an incredible future that we can look forward to. Let me turn and recognize the Chairman of the full committee, Senator Carper.

Senator CARPER. Thanks. I appreciate, Senator Merkley, your letting me slip ahead of you. Thank you so much. First of all, let me just say, I appreciate you having the hearing today.

The largest source of carbon dioxide emissions, carbon emissions, greenhouse gas emissions, come from our mobile sources. I think it is about 30 percent, about 25 percent from power plants, about 20 percent from manufacturing operations, including cement plants, including steel mills, that kind of thing. We are trying to make sure we focus especially on those three, but including focus on autos.

I will never forget, I have shared this with some of my colleagues before, I used to go to the Detroit Auto Show every January, actually. When Delaware had two big auto plants, a big Chrysler plant and a big General Motors plant, they employed about 3,000 or 4,000 people at each of them. It was a big deal for a little State.

I remember being at the Detroit Auto Show about 10 years ago, and I met a young woman named Mary Barra. For a lot of people, that is a familiar name now, because she is not just the CEO of General Motors, she is the chair of the Business Roundtable.

I met her at a ceremony they had at the Detroit Auto Show to announce what car was selected as car of the year, what SUV or truck was selected as the truck of the year. The car of the year was the Chevrolet Volt, and it was a hybrid. They do not make them anymore, but it was a hybrid. I remember talking with her, and

she told me that it got 38 miles on a charge, and after that, the battery was depleted and the car would have to operate on gasoline, diesel, whatever.

Ten years later, she is a big deal. She is the chairman of the company and chairman of the Business Roundtable. I was trying to get GM, maybe about a year ago, to join Ford and Volvo and some other companies in really signing onto fuel efficiency standards, or emissions standards.

I will never forget what she said to me. She said, Senator, I am all in on electric. That is where the future is. They are cheaper to build, to maintain, and climate change is real. It makes sense. She said, three things have to happen before people will buy the vehicles that we are prepared to make, the electric vehicles we are prepared to make in the future.

No. 1, 300 miles range. She said, that is on the industry, not on the government. She said, the second thing we need is the ability to charge batteries in minutes, not hours. That is on the industry; that is not on the government. She said the third thing is on the government, and that is to make sure that we have throughout not just Delaware and places on the East Coast, but all over the Country, charging stations and fueling stations for vehicles that we are prepared to build. She said, if we do not do that, we will never be as successful here as we would like to.

Another conversation that I remember was with a person, I remember a conversation with, I think it was Amazon and FedEx. They were talking about their delivery vehicles and whether or not they use electric vehicles, do they use diesel vehicles, some combination thereof.

I am not sure if it was Amazon or FedEx, but over a relatively short period of time, they migrated almost entirely to electric. They did it, and I will never forget them explaining to me. The fellow we talked to from whichever company it was said that, the right business decision for us, set aside concerns about climate change or global warming or sea level rise, for us, the right business decision was electric vehicles.

Same reasons that Mary Barra had given me. It is not just low emissions; it is low maintenance. They are easy to build, easier to maintain. She did not say this, but as the owner of an electric vehicle that I have had now for about two years, they are fun to drive. That is kind of hard to put a price tag on, but they are just a hell of a lot of fun. For people who, I can see some heads in the audience here nodding, yes, they really are.

For those reasons, I think that is where we need to go, ought to go. Having said that, 10, 15, 20, my last vehicle was a 2001 Chrysler Town and Country Minivan with 600,000 miles on it. Some people just love their vehicles. Maybe some people in the audience love their vehicles and never want to change, and they are going to keep their vehicles for 100,000, 200,000 miles, maybe more. We are not going to hit a switch and just move over and take EVs, or hydrogen-powered vehicles, but we will eventually migrate away.

The other thing I would just say, I mentioned in another hearing today what we are facing in terms of climate change, sea level rise, and that sort of thing. We have to be smart enough to not let this happen. The question is, are we smart enough to avoid the dire

consequences that we hear about all the time, are we smart enough to do that, and at the same time, create jobs and economic opportunity?

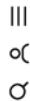
I would take away from my conversations with Mary Barra and the folks at General Motors, and frankly, Bill Ford at Ford Motors and the folks at Amazon, the delivery company or FedEx that offered the very smart, I thought, coaching arguments for supporting EVs. There we go. We do not have to do it just because it feels good, but it is actually good business sense.

My wife and I have some four step-grandchildren. I want to make sure that they grow up and have a planet to grow up on and grow old on and have good jobs. It comes to that.

Mr. Chair, I want to ask unanimous consent a study by the International Energy Agency that compares the greenhouse gas life cycle analysis between an internal combustion vehicle and battery electric vehicles. It is hard to read my staff's writing, but then considering the mining of critical minerals electric vehicles are substantially less in emissions compared to internal combustion vehicles. We will change this for the record, but I think I am asking unanimous consent for a study by the International Energy Agency, here.

Senator MARKEY. Without objection, so ordered.

[The referenced information follows:]

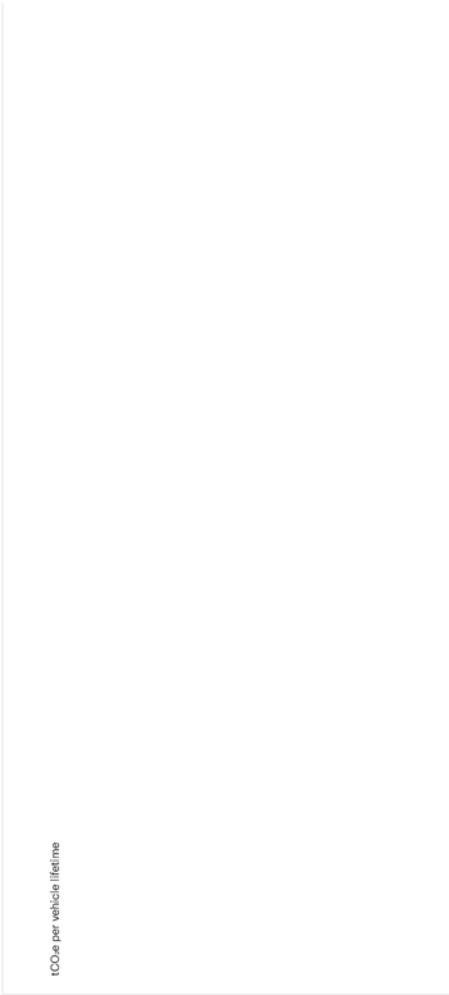


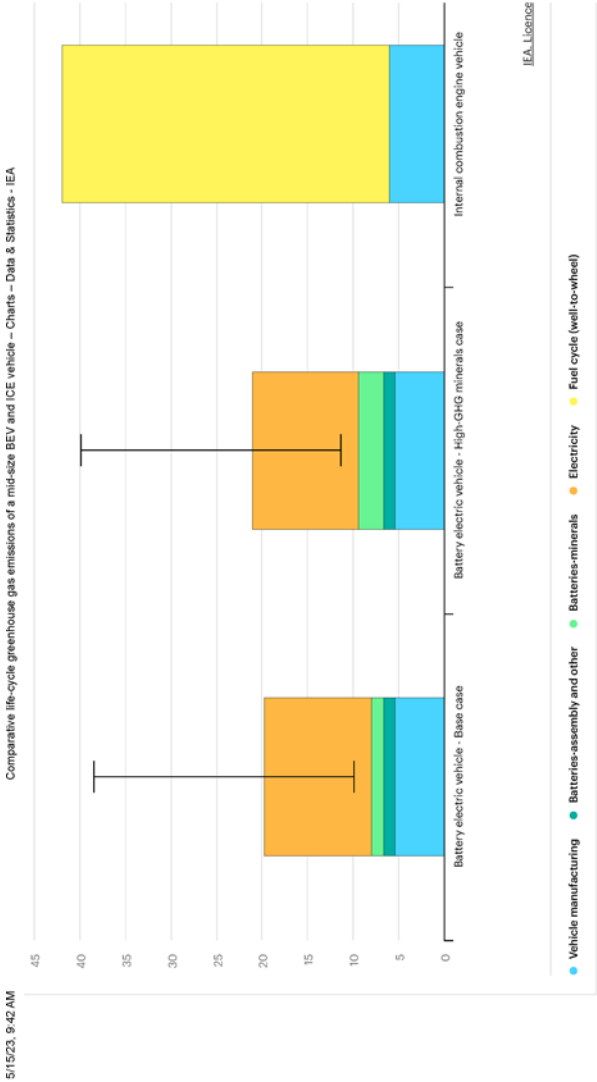
Comparative life-cycle greenhouse gas emissions of a mid-size BEV and ICE vehicle

Last updated 26 Oct 2022

Download chart

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Appears in

[The Role of Critical Minerals in Clean Energy Transitions](#)

Sources

IEA analysis based on IEA (2020c); Kelly et al. (2020); Argonne National Laboratory (2020).

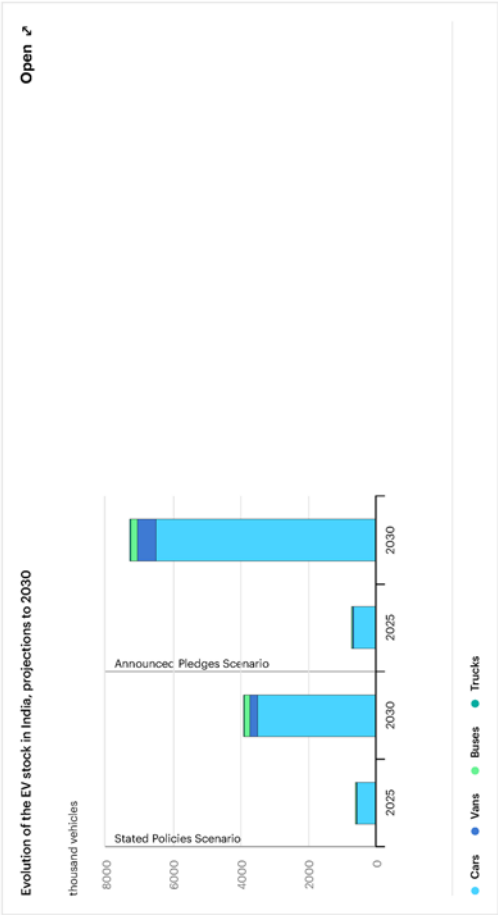
Notes

The "High-GHG minerals" case assumes double the GHG emission intensity for battery minerals (70 kgCO₂-eq/kWh compared to 35 kgCO₂-eq/kWh in the base case; other assumptions are the same). Values are for a vehicle manufactured from today's manufacturing lines assuming dynamic global average grid carbon intensity in the SDS (including transmissions, distribution and charging weighted for mileage decay over a 20-year lifetime). The ranges shown for BEV represent cases for charging with a static low-carbon (50 gCO₂-eq/kWh) and high-carbon electricity mix (800 gCO₂-eq/kWh).

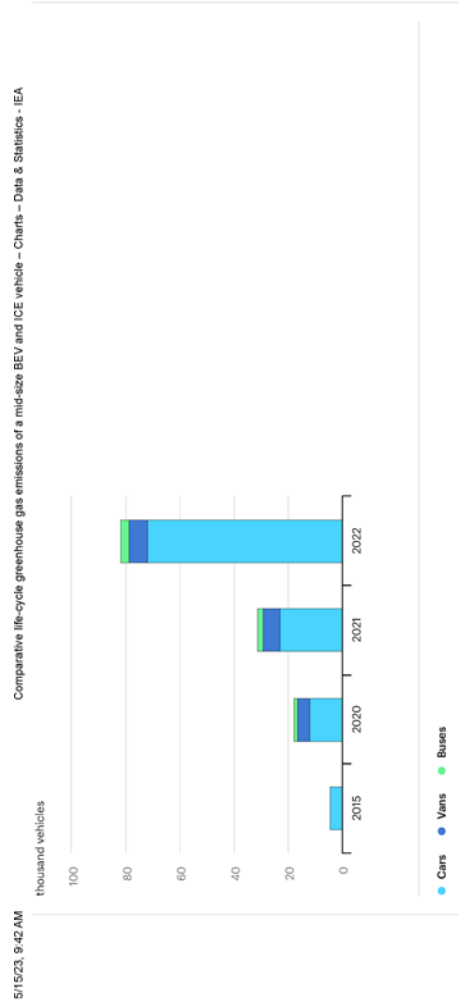
<https://www.iea.org/data-and-statistics/charts/comparative-life-cycle-greenhouse-gas-emissions-of-a-mid-size-bev-and-ice-vehicle>

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Related charts



Historical evolution of the EV stock in India, 2015-2021





Analysis Data and statistics

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Senator CARPER. I have a question for Mr. Harto, and then I will be out of your hair.

I want to thank the Chair for holding a hearing on a transportation sector that I have suggested as a major source of carbon emissions, and we have to do something about it. We are doing something about it. EPA's newly proposed light duty vehicle and heavy-duty vehicles greenhouse gas emissions standards will reduce emissions of criteria pollutants, greenhouse gases, and air toxics, creating significant benefits for public health and our climate.

This issue is especially personal for us in Delaware. I think I have mentioned a million times, my committee members can tell you, a million times how Delaware is the lowest-lying State in the Country. Our State is sinking. The seas around us are rising. It is not a good combination.

Here is my question for you, Mr. Harto. We always talk about the tremendous clean air and climate benefits of EPA's Clean Car Rule, but as a car enthusiast with, as I said earlier, my own electric vehicle, I also want to hear about what these rules will mean for American drivers.

Does your research show that many drivers want to buy electric vehicles, and if so, why? How will these clean car rules help protect drivers from volatile global oil prices, which are often influenced by the whims of dictators?

Mr. HARTO. Great. Yes, thank you for your question.

Yes. These rules will deliver consumer savings to Americans. EVs on the road today, despite their higher prices, already deliver lifetime cost savings to consumers while reducing the volatility of their monthly fuel budget. Electricity prices change over time, but they change very slowly, in fairly predictable ways, whereas oil prices fluctuate wildly, which can, even if you thought you could afford the vehicle when you first bought it, if oil prices rise \$1, \$2, you might have to choose between feeding your family and fueling your vehicle to get to work every day.

Senator CARPER. Anybody else want to comment on that? Ms. Harris?

Ms. HARRIS. Thank you so much, Senator.

Just uplifting what Mr. Harto said, we are already today seeing significant cost savings for an electric vehicle compared to a gasoline-powered car. Since the transportation costs tend to be a large energy burden for drivers and consumers, transitioning to zero emission vehicles is a win for consumers' pocketbooks as well, in addition to a lot of the points that you uplifted for improving air quality and health of Americans and also making us more globally competitive, too. There are many, many benefits, and there is an increased interest from drivers to purchase these vehicles.

Mr. BOYLE. Senator Carper, if I may?

Senator CARPER. I was just handed notice that I need to go give a speech on the floor right now. If I could be, I should be two people right now, but I apologize, I need to run. I welcome anything you want to give us for the record, please and thank you.

Mr. BOYLE. Thank you.

Senator CARPER. Thanks so much.

Senator MARKEY. The Senator's time has expired, and his request for inclusion in the record of the document that he referred to, without objection, they would be so ordered.

The Senator from Oregon?

Senator MERKLEY. Thank you very much, Mr. Chairman, and greetings to all. Thank you for your testimony. I just want to repeat what I heard you all saying, Mr. Harto, that life cycle costs for a consumer, they are better off buying an electric vehicle?

Mr. BOYLE. That is correct.

Senator MERKLEY. Do you agree with that, Ms. Harris?

Ms. HARRIS. Yes.

Senator MERKLEY. If I am buying an electric vehicle, and I am wondering, well, how many miles am I going to get on a kilowatt hour, what is the answer?

Ms. HARRIS. A recent study that I saw said that the average range of an electric vehicle today is about 290 miles.

Senator MERKLEY. That is not the range. How far am I going to go on a kilowatt hour?

Mr. HARTO. Somewhere between three and four miles per kilowatt hour.

Senator MERKLEY. Four miles on most of the Bolt, for example. I pay 12 cents for each kilowatt hour that comes to my house. Therefore, it costs me how much to go one mile?

Mr. HARTO. About three or four cents.

Senator MERKLEY. Three cents. Brilliant. That is incredible. I think that is why the life cycle savings are significant, not to mention the savings when you have an internal combustion vehicle doing tens of thousands of little explosions that have to be managed, they have all kinds of parts to repair that you do not have on an electric vehicle.

I did, however, have a problem in that a mouse got under the hood of my Bolt and ate a bunch of key wires out of reach. I did have to have one repair, unfortunately.

Well, I have a 360 square foot, 20-panel solar panels on my roof. Well, this month, they produce about 30 kilowatt hours a day, just 360 square feet, which means that the average mileage that I get from my car out of this little, tiny solar array on my roof is about 120 miles. I can drive my car 120 miles a day on the electricity coming in on that little tiny array on my roof. To me, that is incredible.

I think it is helpful for people to hear those basic numbers, because it does not translate initially that just a little bit of panels on your roof, and you can drive. Well, think about that. If you are doing a hundred miles a day, for a year, that is 36,000 miles on just that little sunlight coming in on your roof.

Anyway, it has to be, however, when you are on the road, outside of the range of your fueling up at home, charging up at home, it has to be as easy to charge up as it is to fill up. Have we reached that point yet, either one of you?

Mr. HARTO. No, we have not, but these EPA standards really help solve the chicken and egg problem with charging infrastructure. Private industry is not going to invest billions of dollars in putting in chargers if they are not sure that the vehicles that need them are going to be there. Industry promises only go so far. Hav-

ing set rules really sets a direction for the industry and allows them to invest with confidence.

Senator MERKLEY. Well, we do have to grow the charging stations and grow the number of vehicles, but something else that would be helpful, and I have sent a number of letters to our Transportation Secretary, I have had many conversations with him about this, is the complexity of charging when you find that station that is open. Some of them charge monthly fees. Some of them charge by how much time you are hooked up. Some of the charge by kilowatt hour, but do not tell you what the charge is, and so forth.

My advocacy to the Transportation Secretary is making it as transparent as gas stations are. Every single one of them, you know what you pay per gallon before you drive in. Can we do the same and have people know how much they are going to pay per kilowatt hour when you bring it up to the charging station? Would that be a good idea?

Mr. HARTO. Sure, yes. Sounds great.

Senator MERKLEY. Those are softball questions, maybe leading questions. Some stations charge 15 cents in Oregon. Some charge 45 cents, and you do not really know until you get there. That will really help, because there is a certain anxiety about the complexity of charging stations that is totally unnecessary.

So, with the grants that we have in the legislation we passed last year, my argument was, require people to standardize in a way to get rid of that anxiety about the complexity of a charging station. For folks who travel a lot, you eventually figure out the system. You figure out how to check the apps, but it does not need to be that hard.

I read, Mr. Harto, that 36 percent of Americans were definitely or seriously considering an electric vehicle. I certainly, after having one, understand that there is a lot to love. What is the main reason Americans are considering an electric vehicle? Is it the cost savings that you referred to? Because I think most Americans do not really know that yet. Is it how quiet they are, is it the lack of repairs, is it the environmental sensitivity? What is driving their interest?

Mr. HARTO. Every American has their own reasons for choosing an electric vehicle. Some of them choose them for climate reasons; some of them choose them for cost reasons. Others just like that they are faster and perform better, and they enjoy driving them. There are a lot of different entry points for Americans into electric vehicles.

Senator MERKLEY. Any insights, Ms. Harris, on what are considered the top two drivers for people's interest in electric vehicles?

Ms. HARRIS. Nothing more to add than what Mr. Harto said. I think there are a variety of reasons, but I do think that the cost savings for drivers is definitely one of the reasons why they continue to purchase electric vehicles.

Senator MERKLEY. I must say, early on in the electric vehicle world, it was the glue yourself to the back of your seat acceleration that put a big smile on a lot of people's faces. I must say, I nearly wrecked an electric vehicle the first time I drove one, because it was like—I was on the freeway before I knew what had happened. I am glad I made it through that, otherwise I would not be here today.

My time has expired, so I am going to turn it back over to the Chairman. Thanks.

Senator MARKEY. Thank you. Now, we will turn and recognize the Senator from Alaska. Mr. Sullivan?

Senator SULLIVAN. Thank you, Mr. Chairman. Thank you to our witnesses.

Mr. Boyle, I would like to focus on some of the issues relating to the trucking industry. There has been a really good story on the fact that 70 percent of our economy's total tonnage has been coming from you and your industry, and there has been very significant greenhouse gas emission reductions, primarily through your own work. Isn't that true?

Mr. BOYLE. Yes, sir.

Senator SULLIVAN. Do you think that has been highlighted much?

Mr. BOYLE. You know, the line of demarcation that most people refer to with diesel technology emissions was 2010. Right now, if we look at the national fleet of Class A trucks, 47 percent of them are still pre-2010. There is an 83 percent reduction going from 2010 to today. Senator Carper and others have actually facilitated legislation grants to help refresh this fleet. We want to remove impediments for people to buy today's trucks.

Senator SULLIVAN. That is going to help make the environment cleaner, correct?

Mr. BOYLE. With the existing infrastructure, without the trillion-dollar investment, yes.

Senator SULLIVAN. Well, listen, I think that is a story that we need to hear more about. I am very concerned, like many, bipartisan concern, by the way, of the EPA's using its regulatory power to the transition vehicle fleet in a way which I think is not an achievable pace. These rules are de facto bans on internal combustion engines, and that is why Senator Ricketts and I intend to introduce resolutions of disapproval under the congressional Review Act both for heavy duty truck proposals and EPA light and medium vehicle proposals. I ask, Mr. Chairman, unanimous consent to enter into the record a recent op ed from the Wall Street Journal, saying Biden's EPA rules remake the auto industry.

Senator MARKEY. Without objection.

[The referenced information follows:]

Biden's EPA Remakes the Auto Industry

His new car rules are a de facto order to make and buy EVs.

By The Editorial Board
April 12, 2023 6:50 pm ET



EPA Administrator Michael Regan PHOTO: ERIC LEE/BLOOMBERG NEWS

The U.S. auto industry is nominally still privately owned, but it is slowly becoming a de facto state-directed utility. That's the meaning of the Environmental Protection Agency's proposed new vehicle-emissions standards Wednesday that will force-feed the production of electric vehicles, whether or not consumers want them.

The EPA is using its authority under the Clean Air Act to regulate tailpipe pollutants. But make no mistake this isn't about clean air. This is about forcing auto makers to produce more EVs that consumers will have no choice but to buy since there will be few gas-powered vehicles left.

The EPA lacks the legal authority to mandate EVs, but it will do so indirectly by setting CO₂ emissions standards for 2027 through 2032. The standards are so strict that auto makers must electrify their fleets to meet them. Under the proposed rules, EVs would account for about two-thirds of light-duty vehicle sales in 2032, up from a mere 6% or so last year.

The EPA mandate is even more aggressive than President Biden's August 2021 executive order, which set a goal of 50% EV sales in 2030. EPA says at least 20 countries have announced plans to phase out internal-combustion engine cars in the coming decades, so its proposal is no big deal.

"In February 2023 the European Union gave preliminary approval to a measure to phase out sales of ICE passenger vehicles in its 27 member countries by 2035," EPA says. It conveniently ignores that the European Union last month [walked back the ban](#) amid concerns about its enormous costs.

Auto makers such as Ford and [Stellantis](#) have recently announced layoffs owing to rising EV costs. They are shifting investment to EVs from internal-combustion engines, meaning fewer gas-powered cars for sale with higher prices. Gas-powered cars are subsidizing EVs, which aren't profitable though they cost 10% to 40% more than alternatives.

The EPA nonetheless says its rules are feasible because of the Inflation Reduction Act's (IRA) subsidies. A recent [Goldman Sachs](#) report estimates that electric-vehicle consumer and battery-production tax credits alone could cost taxpayers \$523 billion over 10 years.

Even with the IRA subsidies, the Energy Information Administration last month forecast that EVs will make up only 15% of sales in 2030 and 19% by 2050. While EVs are becoming more popular in the luxury class, they "remain less competitive against conventional gasoline-powered cars and light trucks serving the mass market," the report noted.

Reasons include higher prices and insurance costs, a battery range that typically tops off at 250 miles and long charging time. Even rapid chargers take 20 to 30 minutes, which most people don't want to spend while driving children to soccer or baseball games.

EVs now appeal mainly to the affluent who live in urban areas and don't travel long distances. [Tesla](#) accounted for 64% of the U.S. EV market last year. Traditional car makers can make more EVs to meet the EPA standards, but if consumers don't buy them, the companies will have to buy compliance credits from Tesla or other luxury EV makers.

Tesla has raked in \$4.8 billion over the last three years from such credit sales. All this explains why auto companies are kvetching. "EPA's proposed emissions plan is aggressive by any measure," the auto maker lobby said. "This requires a massive, 100-year change to the U.S. industrial base and the way Americans drive." That may be an understatement.

While the rules don't dictate the specific cars or models that must be made, the Administration is remaking a major industry in a way that is unprecedented in a free-market economy. This is Chinese-style central planning, as auto makers answer first to their political overlords rather than consumers and investors.

The auto companies might deserve sympathy if their executives hadn't become political supplicants. In addition to lobbying for subsidies, they intervened to defend the Administration's recent emissions standards against a legal challenge by GOP state attorneys general. They sold themselves out to the government for subsidies, and now they are pleading for more subsidies to meet its mandates.

Democrats and auto makers say EVs are the future, but then why does the government have to subsidize and mandate them? The government didn't have to force Henry Ford to make his Model T, nor consumers to buy [Apple's](#) iPhone. The left's problem is that current EV technology and costs limit their appeal.

The Administration's coercive EV transition is being done in the name of reducing CO₂ emissions, but it will have almost no effect on the climate. Climate has become the political cudgel to remake entire industries and coerce Americans to do what progressives want. They don't believe Americans are enlightened enough to make their own choices.

Appeared in the April 13, 2023, print edition as 'Biden Remakes the Auto Industry'.

Senator SULLIVAN. Thank you. Mr. Boyle, do you agree that the regulations are an unprecedented move by the EPA to dramatically move forward something that we think probably violates the recent Supreme Court decision in EPA versus West Virginia in terms of, if you are going to regulatory authority to remake the whole economy, you need to get that authority from the Congress. What is your view on that?

Mr. BOYLE. We work in interState commerce. My trucks transport cancer drugs. When we impede interState commerce, the products that are essential to daily life do not get delivered. Yes, by passing the buck and allowing States to enact their own regulations on emissions, the market is not large enough for innovators to address individual States.

Furthermore, yes, historically, we have had great, our OEMs and other stakeholders in industry have great cooperation and collaboration with EPA on technical standards and on timelines that were achievable. If we do not do that, and we cede to the States, we end up with this patchwork.

Then, furthermore, as we discussed earlier, as of January of this coming year, there will be no internal combustion truck that is compliant with California Carb Standards. Battery electric trucks, if everybody in this room took off their socks and shoes and we counted fingers and toes, we would have more of them than there are chargers for heavy duty trucks.

We have to play a little bit more chess, not checkers, get the power generation, establish the infrastructure for chargers and then, by all means, we would embrace this notion. To do so without that in place sets trucking up for failure which in turn, sets up consumers for failure and higher costs.

Senator SULLIVAN. Thank you.

Let me ask one final question for all the panelists. The Administration, and I think this is a bipartisan issue, says that they want America, not China in particular, to source the critical minerals that we will need for electric vehicles and so many other clean energy technologies. Yet, this kind of timeline does not give our Country the ability to mine critical minerals that we have.

By the way, in Alaska, we have the highest environmental standards in the world on mining critical minerals. If we need critical minerals, and we want to get away from China, the reliance on China, and we have the highest standards in the world and we can employ our own people, why wouldn't we do that?

You may have seen Senator Manchin's statement on what he called the EPA's radical vehicle emissions standards, and he said that the one thing that is going to happen here is that it is going to only result in more energy secure and powerful China and strengthening our reliance on minerals and technologies from China. This is a Democrat saying this.

I am meeting with, in the next couple minutes, a group from the Ambler Mining District in Alaska. Huge critical minerals supply for our great State. Highest environmental standards, labor, Tribal, individuals I am going to be meeting with on this Ambler project. The Biden Administration, on the day the President held a critical minerals summit, reversed the 7-year environmental impact statement on the Ambler mining road.

It is crazy. If we need green technologies and we need the critical minerals for it, why wouldn't we do it from here? Why would we keep relying on China? The Administration recently took a very large critical mineral deposit in Minnesota offline for 20 years. All this does is make us more reliant on China, and they have the worst environmental standards in the world.

Would anyone like to comment on this? If we need these technologies and minerals, why wouldn't we get it in the place with the highest standards on the planet? That is America. That is Alaska. Yet, this Administration talks a big game, and all they do is undertake policies that make us more reliant on the Chinese Communist Party and its economy.

Any views on that? I will throw it open to anybody. Mr. Boyle, we will start with you.

Mr. BOYLE. Certainly, national security needs to be taken into consideration. If we expose ourselves, we are just moving from one commodity to another.

Senator SULLIVAN. Ms. Harris, any views on that, just wanting to source critical minerals in the place that has the highest standards in the world, which is us?

Ms. HARRIS. Yes, of course, thanks for the question, Senator. Thanks to Congress passing the Inflation Reduction Act, the U.S. is now on course to insource much of the battery production while also having minerals sourced from countries that we have trade agreements with;

Senator SULLIVAN. And our allies, right?

Ms. HARRIS. Yes. I will highlight, too, that these rules are being complemented by U.S. programs to reduce, reuse, and recycle the minerals from batteries so that we can reduce the need for additional extraction.

Senator SULLIVAN. Good. You agree with focusing on American production, mineral production, or our allies, who have much higher standards than the Democratic Republic of the Congo and China, correct?

Ms. HARRIS. Yes, and we are seeing automakers also bring this industry onshore already, with over \$210 billion of investments just here in the United States to help with that process.

Senator SULLIVAN. Good, excellent.

Mr. Harto, do you have a view on that, as well?

Mr. HARTO. I have nothing more to add from what has already been said.

Senator SULLIVAN. OK, thank you. One point five partisan agreement. I think everybody here agrees with this.

Mr. BOYLE. It is worth noting, to your point, if we were to convert the entire U.S. trucking fleet to battery electric, we would need to commandeer global production of lithium for more than seven years.

Senator SULLIVAN. Yes.

Mr. BOYLE. That is the scale of the problem we are talking about. It is not that we can not overcome challenges, but we do not overcome them by pretending they do not exist. We just manifest our own destiny that way.

Senator SULLIVAN. A lot of the challenges we have, Mr. Chairman, as you know, we can solve here, in America, with our own

high standards on the environment and production. I think it is a good area of bipartisan cooperation. I am glad all the witnesses are in agreement. Thank you very much.

Senator MARKEY. I thank the gentleman.

After the Waxman-Markey bill passed, I traveled immediately to China, waiting for it to pass the Senate. We actually went to a wind turbine manufacturing facility. It was massive. We did not have an equivalent in the United States. I said, those wind turbines are pointing at the American economy in the same way that the Russian missiles were pointing at the United States during the Cuban Missile Crisis.

We need a response, and that is what the IRA is. It is saying, domestic manufacture, domestic sourcing, only with our allies, and let us just put this thing together, because we have been asleep, allowing for this erosion of our own domestic capacity. I think it is an area where we can partner.

Let me turn to the Senator from California.

Senator PADILLA. Thank you, Mr. Chairman. I appreciate your holding this important and timely hearing today.

I just want to start by saying I am so proud of the efforts that you have led, that I have tried to lead, along with Chairman Carper pushing the EPA to finalize the strongest possible vehicle emissions rules.

I am starting to like this subcommittee and this committee as a whole, because it seems like every time I walk in from another committee, I am told that they were bashing California again for the audacity to exercise some policy leadership. Let me just say that you are absolutely right. We are setting the bar high, but we are also thoughtful enough, from the Governor, the legislature, the congressional delegation, on down to be thoughtful about a transition from fossil fuel vehicles to electric.

The deadlines that have been set are not tomorrow or next week or next month. We know that there is a transition that needs to take place. By setting out a marker several years, we know that technology will continue to improve, performance of those technologies will continue to improve in that timeframe, not just batteries, but all aspects of electric vehicles, for example, passenger vehicles, to heavy duty trucks, even locomotives eventually, but also modernizing the electrical grid to handle the transition to the transportation sector that we are mindful of.

So, give us some credit, that we were thoughtful about this, and already showing some significant progress.

Focusing on today's hearing though, EPA's latest rules are important for so many reasons. They are going to save drivers money on gas. They are going to create high quality jobs in the process and continue to position the United States as a leader in zero emission vehicle technology.

Equally important, and I want to make sure this is not lost on anybody, equally important to my constituents are the public health protections that come from cleaning up vehicles, particularly in the heavy-duty sector. I can not tell you how often I hear from constituents who just want to be able to breathe clean air outside, go outside and play with their kids, and live healthy lives.

I hear frequently from constituents all over California, but particularly in the Inland Empire that is the Nation's capital when it comes to logistics, we all know people love, in this day and age, getting products, whatever they buy online, literally delivered to your doorstep. We have to understand that convenience comes with a significant cost to the public health of Californians, not just, but especially in the Inland Empire.

Mr. Harto, I appreciate your testimony and your organization's reports that shine a light on the environmental injustices happening in the Inland Empire in California, often referred to, as I said, America's logistics capital. The reports show that the impacts of the rapid expansion of warehouses in the area disproportionately fall on low-income communities and communities of color, which increases air pollution in the area due to trucks that burn fuel and transport goods to and from warehouses, to and from ports, and to and from homes.

Can you speak for a minute on how EPA's proposed Heavy Duty Rule will mitigate air pollution in these communities?

Mr. HARTO. Yes, thank you for your questions. I will admit, I have not had a chance to dig too deeply into the EPA's proposal on the Heavy Duty Rule, but we know that decarbonizing and removing emissions from these vehicles that are driving around communities in people's front yards, where children are playing in communities, is extremely important to improving the health of all Americans, especially Americans who live in disadvantaged communities.

Senator PADILLA. Suffice it to say, we have made and can appreciate the significant progress in cleaning up the passenger vehicle sector. We can only imagine the positive benefit that will come with cleaning up the heavy-duty vehicle sector, as well.

One followup question in my time remaining. I have been fighting for the cleaner trucks since I first came to the Senate from pushing EPA to originally revise the standards back in 2021 to moving the Clean Trucks Plan to the proposed phase three standards that we are discussing today.

Question for Ms. Harris. The NRDC has written about how the final phase three standards need to aim higher in order to reduce trucking pollution and put the trucking industry on a path to zero emissions. What do they mean by aiming higher? Can you describe what being more ambitious means to you?

Ms. HARRIS. Sure. EPA's truck standards are an important step forward, but the main proposal is much too weak. Truck makers have shown that they can deliver less polluting and zero polluting vehicles, and EPA needs standards that will get them, to get them on the road. This is especially true given the historic incentives for electric heavy-duty vehicles that were included in last year's Inflation Reduction Act.

To your point, we are going to be working with our partners in communities near highways and ports and freight hubs nationwide to deliver data to the Environmental Protection Agency showing how and why this pollution can be cleaned up, and why it must be cleaned up now.

Senator PADILLA. Thank you.

In closing, Mr. Chair, I will just reiterate my invitation to any of our colleagues who want to see the future of a cleaner transportation sector in progress, I am happy to welcome you to California. Thank you very much.

Senator MARKEY. Of course, we always take that as a challenge, especially since what they do in California is that they take people who are educated at the Massachusetts Institute of Technology (MIT), elect them to the U.S. Senate, then challenge Massachusetts to develop better, more innovative people. We accept the challenge, as we have in the past.

[Laughter.]

Senator MARKEY. We do not have a choice here. We really do not. I have the great honor, as a Member of Congress, this is how long I have been around, I voted to bail out Chrysler in 1979. They were going bankrupt because they had fallen so far behind technologically. Then, I had the honor in 2009 of voting to bail out Chrysler, because they had fallen behind technologically.

We can keep waiting for them to get it, and they would keep saying, oh, Tesla, that is not the future. Do you know how hard it is? People do not want to drive around in an electric vehicle, like a golf cart. They did not have the vision to see what an electric vehicle could be, more powerful than an internal combustion engine vehicle.

So, now they are hustling to catch up, finally, thank God they are, and it is about time. In Europe, for example, the European parliament has committed to making all new cars and vans in Europe to be zero emission by 2035. If we want to be selling vehicles in Europe, we better get moving, here. That is the market.

If we do not want to be in the market, of course we can go slow. We could have a bill to bail out auto companies in 2031 because they are going too slow, and people are not buying them, or in China, if we want to look at Asian markets, we better be making vehicles that they want to purchase.

That just comes down to what Senator Padilla is talking about, that we need to have a way to continue to innovate and get out there. Take them on. We do not want to keep them out. We want to ultimately take them on. Let's have this battle. We have to have the battle on our terms, so that we are not Uncle Sucker here, just importing all of their raw materials.

There are different levels of heavy-duty vehicles. Some are easier to electrify, no question about it. A school bus is easier to electrify than a long-haul truck.

That is why EPA rules to regulate different classes of heavy-duty vehicles are different, giving more leeway and a longer ramp to the vehicles that are hardest to electrify. We can work with the industry on this subject.

But I will just say this, and I hate to do this before the Senator from California leaves, because I am going to cite the Lawrence Berkeley National Laboratory in California for a study which they have completed that finds that zero emission freight trucks are primed for success, because in their assessment, an average long-haul trucker goes 150 miles between 30-minute driver breaks.

So if we deploy fast chargers across this Country, we can electrify those truck routes and save 13 percent for the owners of those

trucks per mile, if we do it right. We are going to have to do it right, there is no question. We are going to have to do it in the correct sequence.

Of course, buses and other vehicles of that nature are going to be easier than the kind of vehicles that Mr. Boyle is talking about.

But we can do this, reflecting the truck stops that, for safety purposes, truck drivers have to accommodate anyway. It will have to be done in a massive enough future.

Again, from Massachusetts, I thank the Senator for all of the great work from the State of California as well. Thank you.

Let me just ask, if I may, one final question before I turn it over to Senator Ricketts. That would be, battery efficiency and the efficiency benefits that we get if this EPA supported battery efficiency standards for vehicles as part of the rulemaking process. Could you speak to that?

Mr. HARTO. Yes, I can take that question. Thank you.

Not enough is talked about on efficiency of electric vehicles. Increasing the efficiency of EVs reduces the cost, reduces the amount of batteries, and allows the vehicles to travel greater distance on the same amount of electricity. Ensuring that the EVs that are built are as efficient as possible is great for everybody.

Senator MARKEY. The EPA is considering the treatment of upstream emissions from plug-in hybrid electric vehicles and battery electric vehicles. I really do believe it is an area where we can put the strongest possible standards in place, and the whole system would benefit greatly.

Let me turn and recognize Senator Ricketts one more time.

Senator RICKETTS. Thank you, Mr. Chairman.

Ms. Harris, Mr. Harto, both of you mentioned that when it comes to securing these critical minerals, that we can work with our allies, and certainly, Canada is obviously a very close ally. I think you mentioned Chile, too. Was Argentina the third one that you mentioned?

Mr. HARTO. Australia.

Senator RICKETTS. Australia, OK. Very good.

When it comes to specific items, right, when you have to make a battery, you can not miss anything, or else the battery is not going to work. Is that a fair statement? Like, if you do not have graphite, you can not make the battery work, is that fair?

Mr. HARTO. Sure.

Senator RICKETTS. I think 80 percent of the graphite comes from China. Can these other countries make up the difference of that? Has somebody done, again, for all the critical minerals that are needed for these batteries, has somebody looked at the reserves for these countries and done the math to see that they can actually meet that need? We have heard that you are going to have to, Mr. Boyle, you said 35 percent of the world's minerals we are going to need to do all the heavy trucks, right?

Mr. BOYLE. We would need to commandeer seven years' worth of global production.

Senator RICKETTS. Seven years' worth. Has anybody done that math, looked at the allies and what they can actually provide?

Ms. HARRIS. I believe that there are some studies on that, but I have not. I do not have that in front of me.

Senator RICKETTS. You do not have any personal knowledge of it. Mr. Harto, do you?

Mr. HARTO. Yes, again, we have not dug deep into it, but I will say that, you mentioned graphite. There are methods to make synthetic graphite from coal. We have a lot of coal that is not going to be used here in the United States.

Senator RICKETTS. Do you know how much more expensive that would be to make it?

Mr. HARTO. I do not know offhand.

Senator RICKETTS. OK.

Ms. Harris, I think in your testimony, you said, in your written testimony, rather, you said rural drivers who, on average, tend to drive further and have larger vehicles, stand to benefit the most from identifying their electric vehicles. Is that accurate?

Ms. HARRIS. Yes.

Senator RICKETTS. I believe that the study you were looking at analyzes impacts in Maine, Vermont, Virginia, and Maryland. Is that accurate?

Ms. HARRIS. I believe so, yes.

Senator RICKETTS. Just out of curiosity, do you know how long it take to drive north to south in Maryland?

Ms. HARRIS. I do not have that estimate in front of me.

Senator RICKETTS. About four hours.

Ms. HARRIS. Yes.

Senator RICKETTS. What about Vermont? Have you any idea?

Ms. HARRIS. I would estimate two to three hours.

Senator RICKETTS. Actually, it is about four hours and 40 minutes, so it is a little bit longer in Vermont.

Nebraska is about seven hours. If you look at not just how long it takes to drive back and forth, but also the square mileage, if you look at the States that you cited in your study, Maryland is about a sixth the size of Nebraska; Vermont is an eighth the size. Maine is about half the size, a little bit less, and Virginia is a little more than a half of it.

My point being that these States are not typical for what you would find in the Western United States as far as rural States. Trying to get at how it is going to impact people in those States is one of the challenges. In fact, that is one of the things that I have noticed since I have come here to Washington, DC.

Again, to Senator Carper's point, driving electric vehicles, they are fun. They have great acceleration. It is great that we can have fun with them like that. I think one of the things that I have seen here in Washington, DC. in my short time is that when you are around big urban areas, you have a different perspective on how you can use electric vehicles and the access to charging stations and so forth versus a rural State like Nebraska, where you have two metropolitan areas that would not even be considered big on the East Coast and a lot of open space in between where you do not have a lot of people. We have, for example, three times as many cows as we have people.

You have to drive long distances to be able to get anywhere, and I mentioned the stretch between Allen and Hay Springs, 340 miles, there are no charging stations. Even with the \$6 million a year I think Nebraska is going to be getting from the stimulus package

that got passed, you are not going to be able build that out in time to be able to have two-thirds in effect, in my humble opinion, by 2032. That is a lot of infrastructure.

We are challenged with that right now when it comes to just getting broadband out to our Nebraska households. That is a billion-dollar investment there, to be able to get just broadband to every household in Nebraska. Trying to do charging stations is going to be another drop, and then again.

Just in my experience as Governor, working with our public power districts, we are the only public power State in the Country, just providing, for example, Google and Facebook, which use a lot of electricity, have come to our State, and economic development, creating jobs, they use a lot of electricity. You just do not pop up the kind of electricity it takes to handle those types of facilities.

In fact, in my conversations with Omaha Public Power District (OPPD), Javier Fernandez is their president, it is a challenge to be able to make sure you can keep up with just the growing needs that we have today, none of this is factored into that. None of this is factored into having two-thirds of cars being electric vehicles in less than 10 years. It is not in their plans right now to be able to accommodate that sort of growth in the utility field.

My time has expired, so I yield back. Thank you, Mr. Chairman.

Senator MARKEY. Thank you, Senator.

The Senator from West Virginia is recognized.

Senator CAPITO. Thank you.

Sorry this is a quick in and out, but this is a very topical topic, and I appreciate the three of you and the panel being here today. I am going to jump right in with Mr. Boyle. I understand that your fleet transports sensitive materials that can have strict temperature range requirements. You did a lot of transporting, I believe, of the vaccine?

Mr. BOYLE. Yes, ma'am.

Senator CAPITO. Yes. If you are required to purchase an electric heavy-duty truck, do you have any concerns about the ability to deliver shipments with these kinds of specific temperatures, and are those even available with that kind of technology for an electric heavy-duty truck?

Mr. BOYLE. That is a great point. The draw and the demand is very intense. It is a completely different dynamic than the auto sector.

I would like to address Chairman Markey and Senator Padilla explicitly. We share your concern and your drive toward zero emissions. The trucking industry starts at yes. We are on that path, and we share the concerns about all different communities, rural and urban.

But the path to get there has to be logical. We can not be set up for failure, and in many respects, some of the regulations have caused negative consequences. California actually has among the oldest truck fleets in the Country, so 52 percent of California trucks are pre-2010 diesel emissions. If we got them current to today, that would be an 83 percent reduction with the existing infrastructure.

It is not that we do not want to reduce emissions. We are fully on board with that. It is just that not all solutions, we can not spread the peanut butter from cars onto all vehicles.

Senator CAPITO. Let me ask you this, and it has probably been asked, the cost issue, a new diesel truck in your business, how does that cost? What is the equivalence there for that and an electric truck?

Mr. BOYLE. The upcharge is roughly \$300,000.

Senator CAPITO. That is on top of what the vehicle costs?

Mr. BOYLE. Yes, ma'am, the upcharge, the delta.

Now, as my friends to the right of me here have pointed out, over the cost of ownership, a portion of that may be realized, but not nearly the \$300,000. At some point, yes, it might be somewhat more viable. It is just that we are years away from it. It is simply not an option, because there isn't the infrastructure or power to get to them.

Senator CAPITO. In terms of, let's say, if we are looking 10 years down the road, or if we look 10 years back, would that \$300,000, we expect, I think, and you probably, I do not want to put words in your mouth. Do you expect, I expect, that delta does down over time as there is more, or not?

Mr. BOYLE. The economies of scale that have been discussed previously are in the auto sector where the addressable market is exponentially larger, in the millions of vehicles per year. In trucks, it is a couple hundred thousand, so the market opportunity isn't such that you would have a Moore's law for heavy trucks, for example.

I can tell you, over the course of my career, I have not seen truck prices go down much over time, but yes, could it be compelling and a total cost of ownership at some point? Perhaps, and we are not averse to that. We are certainly not in position to even phase that in at a one percent level at current.

Senator CAPITO. The weight is an issue as well, both for cars and for, I am concerned about, I will go to cars. Cars are going to be heavier. EV cars are going to be heavier because of the weight of the battery and other things.

What kind of safety issues and what kind of State DOTs, what kind of reinforcements along the highways, is that all going to change, accidents, impacts? All of these things I know are critical when you are looking at transforming an entire fleet. I do not know if the trucking industry, by the time you add the weight to the truck, what does that do to the cargo, because there are weight limits, obviously?

Mr. BOYLE. Yes, sure. Each heavy-duty truck electric vehicle battery would be about 8,000 pounds. They are typically in sets of two or three or four. As you add weight in that respect, you reduce the payload capacity. I think another lever for improving congestion and emissions that you have championed, with direct targeted infrastructure investment, and particularly in chokepoints around the Country in a smart fashion, then reducing traffic reduces emissions. That is another lever that the government has at its disposal.

Senator CAPITO. Ms. Harris, I wanted to ask you a question on, in your testimony, you highlight the NRDC support for EVs and

the incentives in the Inflation Reduction Act. The investments that have to be made in battery manufacturing, we know we are beholden to China right now, so we are trying to draw that back into our own Country and have domestically produced critical minerals and chips and everything.

Does the NRDC, are you supporting any domestic mining projects right now that would provide that? Can you name any that your organization does support in terms of creating a mine for critical minerals?

Ms. HARRIS. That is not my area of expertise, but I will say that the auto industry has already committed over \$210 billion to bringing this battery supply chain here to the United States. Many of the incentives that are coming from Congress, including in the Inflation Reduction Act, are not only helping to on-shore some of these supply chains, but are also incentivizing reducing, reusing, and recycling the batteries so that we need to extract less minerals moving forward.

Senator CAPITO. We still have to extract in order to get the domestic production requirements in the Inflation Reduction Act and other things. There are still requirements for, and there is a great desire for us to have domestic materials, whether they are recycled or not, you have to originate. If you are going to have this whole, huge glut of new vehicles or trucks or whatever, or both, you have to have the critical mineral, and you have to have the mine to do it.

We have to have support for permitting reform and for permitting these mines. I question whether your organization would be in favor, and I understand it is not your expertise of domestic mining of some of these critical minerals, which can be very difficult. Thank you.

Ms. HARRIS. Thank you for your question.

Senator MARKEY. Great, thank you. Just a tip of the cap to West Virginia because school buses are considered to be heavy duty;

Senator CAPITO. And they are making them;

Senator MARKEY. And they are making them in West Virginia, so the innovation State of West Virginia has figured out how to make heavy duty buses, school buses, that will be purchased in States all over the Country. They have already made an announcement in West Virginia of 750 jobs in a battery manufacturing plant that is going to be opening down in West Virginia. Congratulations on that, and the fact that it is a company from Somerville, Massachusetts, which is going to use West Virginia for the 750 manufacturing jobs down there.

Senator CAPITO. What company is that?

Senator MARKEY. Form Energy.

That is going to the grid, but again, it is the larger size battery technology that can be developed. For example, I heard Mr. Boyle talking about how when the truck fills up, it goes 1,200 miles, but if you take out that 1,200 mile capacity for oil, that leaves a lot of space for a battery and innovation that can develop that battery that could fill in, because that is a lot of weight that is taken off the truck if you could then replace it with a battery that could use it. West Virginia is at the cutting edge of those issues.

Again, I view this, Mr. Boyle, in a way in which we had these cell phones that were the size of a brick, and then I know because I moved over the 200 megahertz to create the flip-phone era. If you listened to the incumbents at that time, oh my God, you do not know how hard that is, but within three years, everyone had a flip phone by 1995.

And then a very smart kid out in Silicon Valley figured out, you know what, with all that spectrum, I could actually turn it into an iPhone with the capacity of a computer on the Apollo mission in 1969.

So I am very confident that once we set these high goals, with all of the tax incentives that are going to be there, that we will make the breakthroughs, but understanding that you are in an area which will be more difficult, but there are many other heavy duty truck areas that can be solved.

Do you agree with that, that for school buses, for other types of heavy duty but still within a range of technological feasibility to solve that problem in a relatively short period of time?

Mr. BOYLE. You make a great point, sir. It is a massive, diverse industry, and not all operations are the same. However, your previous statement where you used a very important term, sequence, it has to be at the right sequence.

Currently, .001 percent of operations could be supported. That is part of the problem, is that the Clean Trucks Rule, all these things, are way too aggressive based on the current infrastructure. Many carriers are actually making inquiries. When the utility tells you, you are three years out from converting to ten forklifts in a warehouse, I think that should alert us to the fact that we are just not there.

Once again, we are on board with getting there in a gradual fashion, but even come January of this year, we are not quite there. We welcome the opportunity to kind of inform the rule-making and legislative process.

Senator MARKEY. Thank you for that.

Again, the sequencing is important, but we should get those heavy-duty vehicles that we can, and then continue to work, knowing that innovation will help us to accommodate the more difficult areas over time, but still to meet the goal.

One thing, Mr. Harto, that continues to tick me off, is that we import oil from Saudi Arabia, that we import oil from Iraq to put into gasoline tanks in the United States. We put 70 percent of all the oil we consume at the gasoline tanks, when, with innovation, we can just back out that oil.

Can you talk about those benefits, Mr. Harto, for our society, both from a climate and from a national security perspective?

Mr. HARTO. I can talk about it from the perspective of the consumer. From the consumer perspective, not having to worry about the fluctuations in the price of gas as it goes from \$2 a gallon to \$5 a gallon, back to \$3.50 a gallon, and who knows where it goes tomorrow or two weeks from now.

Electrified vehicles, whether they are hybrids, whether they are plug-in hybrids, which would work great in Senator Rickett's State of Nebraska, where people may have to drive long distances without charging infrastructure while still significantly reducing emis-

sions, all of those technologies can reduce consumers' risk to fluctuating oil prices.

Senator MARKEY. Without question. When Saudi Arabia and the Organization of the Petroleum Exporting Countries (OPEC) Plus two weeks ago decided, well, too much oil on the market, we are just going to reduce the amount of oil on the market to drive the price back up again. The equivalent to my father, the truck driver, he can not do anything about it. He has to buy the oil. He does not have a choice. We are just held to whatever the price that this cartel, this essential monopoly, a cartel, wants to charge us.

This gives us a chance to kind of break that link. It will probably help us make more intelligent foreign policy decisions, as well, in terms of this dependence that we have had upon oil over all of the years.

I can not thank all of you enough for your testimony today. In conclusion, when I am going to give you each is one minute to summarize what you want us to know at the conclusion of this hearing. I will go in reverse order of the opening statements and give each one of you that one minute. We will begin with you, Mr. Boyle.

Mr. BOYLE. The trucking industry is not averse to change. We embrace the opportunity to explore alternative fuels and alternative technologies to achieve zero emissions over time.

We are very disappointed with EPA's about-face in terms of the existing rulemaking that manufacturers were trending to and planning for and investing the capital necessary to achieve another significant reduction in emissions.

Second, this kind of punting to a State patchwork of emissions standards is not workable when you are dealing in interstate commerce. The assumptions and the passion for electric vehicles in the car industry and the car segment, I totally appreciate. To extrapolate that onto the trucking industry and the complexities where you can not leverage any of the existing car charging infrastructure is a huge mistake.

We look forward to working constructively both with Congress and the agencies. Thank you.

Senator MARKEY. Thank you so much.

I should have offered Senator Ricketts a final round, as well, which I did not do, and I apologize for that. If you would like to ask questions, let me just give each one of these the 1-minute, and then we will come back to you.

Ms. Harris?

Ms. HARRIS. Thank you so much. One takeaway, three major wins that a transition to—

Senator MARKEY. One minute.

Ms. HARRIS. Oh yes, I will sum it up very quickly. The three wins that we can anticipate through a transition to clean air cars is a win for pollution reductions and for public health. Clean car standards will reduce greenhouse gas emissions and also just improve the health of our communities and our children.

It is a win for consumer pocketbooks and for consumer choice. We know that transitioning to zero emission vehicles can save drivers thousands and thousands of dollars over the life cycle of the vehicle.

And it is a win for the industry and the economy in the United States. We have the opportunity to have a renaissance of manufacturing here in the U.S. and incorporate and increase our competitiveness across the globe.

For these reasons, we are very excited and appreciate the Federal Government's efforts to support this transition. Thank you.

Senator MARKEY. Thank you, Ms. Harris, very much.

Mr. Harto?

Mr. HARTO. Yes. I just want to reiterate my three main points that these EPA standards are achievable, there is consumer demand that is far outpacing supply for electric vehicles, and we see that continuing into the future, and third that, again, EVs already save consumers money, and they will continue to save consumers money far into the future.

Senator MARKEY. Thank you, Mr. Harto, very much.

Again, I apologize to Senator Ricketts. You are recognized for another round of questions.

Senator RICKETTS. Not at all. Thank you very much, Mr. Chairman.

Mr. Harto, you mentioned earlier, you talked about hybrids. I actually agree with you that a hybrid is a better solution with regard to States like Nebraska, where you have longer distances that you have to drive. The EPA has said to attain their standards by 2032, it would have to be something like two-thirds of cars would have to be electric vehicles, if it was only an electric vehicle solution. You also mentioned in your earlier testimony that car manufacturers can do things like hybrids. Correct?

Mr. HARTO. That is correct.

Senator RICKETTS. Do you know, have you done the math, have you seen any studies that show that say, you were going to just assume electric vehicles were going to grow to the current pace, what would hybrid vehicles have to be, what percentage of the new car sales would hybrid vehicles have to be to meet the same sort of attainment standards if you had two-thirds?

Mr. HARTO. Again, we are going to have a mix of solutions in different places. When we did the analysis on a 50 percent target, if an automaker built mostly hybrids, that 50 percent drops down to about 35 percent electric vehicles. Again, an automaker could build 50 percent. I do not know the exact numbers, but they can build a mix. The more hybrids they build, the more plug-in hybrids they build, the fewer battery electric vehicles they have to build.

Senator RICKETTS. Consumer Reports has done that math on that to say how much percentage would have to be to reach these attainment emission standards?

Mr. HARTO. We have not for the current rules. We plan to do some of that analysis in the future. They were just released last week, so we have not had a chance to run the numbers. We have done it on similarly strong standards, and there is a lot of room to apply other technologies.

Senator RICKETTS. OK. Mr. Boyle, we have talked a lot about how the trucking industry is on board with reducing emissions. You have already been doing it. Talk to me a little bit, though, about, you mentioned the patchwork of States also trying to do this.

Can you discuss the impact these rules would have on business development strategy? When you have a change like this, what does it do for your long-term business planning?

Mr. BOYLE. Yes. I hope I conveyed early on how my company is in the top one percent of the top one percent in terms of sustainability performance and initiatives. I can tell you that, tragically, it is not valued in the marketplace.

So one other lever that I would suggest that the Federal Government has at its disposal is to put out a carrot. Think of the purchasing power of the U.S. Postal Service, the General Services Administration (GSA), the Department of Defense. None of those factor in sustainability of the transportation service provider in the procurement decision.

How about we use market forces to entice people to buy newer, cleaner vehicles? And that will enable us to bring that 40 percent of America's fleet that is on the old standard up to current, and that will have, without as much of an investment, that will have a greater impact.

Senator RICKETTS. What about, again, just talking about your own business planning, when you see changes like this, how does that impact your business, specifically?

Mr. BOYLE. I guess we would have to have a lot more trucks to service the same amount of freight, and then we would have to, we really, as of right now, it is not even a consideration to invest in battery electric trucks. The Clean Truck Fleet Rule is not saying, as Senator Markey said, hey, particular applications is more applicable. No, you are looking at, hey, every motor carrier, you have to have this percentage. That is just completely irrational.

Senator RICKETTS. You are saying the regulations do not accommodate what we are talking about, that maybe school buses would be a good application, but long-haul trucks would not be? The regulation is too broad, it is too blunt of an instrument to actually make that, it does not have that nuance. Is that fair?

Mr. BOYLE. That is a great analogy, yes, because all school buses have the same characteristics and operation. Trucking is so massively diverse.

Senator RICKETTS. I thought you just said something about, it is a discouragement to make investments in battery trucks. Is that what you just said?

Mr. BOYLE. Yes. Right now, because, as we said, the sequence, the power generation, if we said right now, 25 new nuclear plants are going in to create clean energy in the Country to feed the grid and other renewables, and then in parallel we are going to build the charging infrastructure, hey, then we are considering it. That is a business decision.

We all want to reduce fuel consumption. That is good business, but without those in place, there is actually no consideration whatsoever.

Senator RICKETTS. Thank you, Mr. Boyle.

Chairman Markey, I would note that under the last Administration, the United States was energy independent before the Biden Administration's policies that reduced the investment by our own companies here in America. We actually did not have to do all that

importation of other fuel, if we would take advantage of our own resources.

Senator MARKEY. No, we were importing oil from Saudi Arabia and other OPEC countries.

Senator RICKETTS. We were a net exporter of energy, and we could be again if we would take advantage of some of the things we talked about today about using our resources. Of course, I do not think anybody is going to do it better than we are with regard to protecting the environment.

Senator MARKEY. I appreciate what you are saying, but if we did not export our own oil, we could have told Saudi Arabia and other countries, we do not need your oil at all. By exporting our own oil, we then need Saudi oil.

In essence, what this revolution is, we are saying to all of the oil companies, we are not going to need your oil. We are going all electric. It is not going to be drill, baby, drill, it is going to be plug in, baby, plug in. It is across the whole oil industry, across domestic and international markets.

I appreciate what you are saying. Ultimately, this plan is one to create jobs in America. Let's just say that. If by the time we have 50 percent of all vehicles here sold in the United States by 2030 are electric, and we do nothing to on-shore the EV supply chain or grow the market share for American-made vehicles, there will be significant job losses in the United States.

But if 50 percent of vehicles sold in the U.S. in 2030 are electric and we increase domestic content and increase the market share of American-made cars, 140,000 new jobs will be created in the United States.

So, implementation of this matters. It is going to be very important for us to make sure that we get this technological and economic and climate justice revolution underway, and that it happens in a fair way with environmental justice for our communities, for union workers, and with intentional implementation of the billions of dollars in new money going to the right places, while the EPA has to deliver that we are, in fact, delivering for those communities that have always been impacted most intensively.

Again, I will just add one more fact that in 2022, the United States was a net petroleum exporter in 2022, so we were in fact exporting more oil that we actually imported in 2022. That is just the reality of where we are today. This is a discussion about how we are moving to the future.

As a matter of housekeeping, I would like to ask unanimous consent to submit for the record a variety of materials that include letters from stakeholders and other materials that relate to today's nomination hearing. Without objection, so ordered.

[The referenced information follows:]

The Washington Post
Democracy Dies in Darkness

Opinion

Biden's new electric car rule puts the country on the wrong road

By Robert E. Grady

April 20, 2023 at 7:00 a.m. EDT

Robert E. Grady served as executive associate director of the Office of Management and Budget under President George H.W. Bush and was one of the principal White House negotiators of the Clean Air Act Amendments of 1990.

The Biden administration's [announcement last week](#) of a new proposed federal rule designed to force adoption of electric vehicles by the car- and truck-buying public bore all the signs of an initiative that sounds good in theory but will be disastrous in practice. The administration got the headlines it wanted, but the proposed rule will likely increase air pollution, be subject to major legal challenges, and represent a step backward in the design of intelligent, consumer-friendly and cost-effective regulation.

Older cars are much dirtier than new ones: According to a [study](#) by Penn's Kleinman Center for Energy Policy, cars more than 10 years old account for between 70 and 80 percent of emissions of smog, carbon monoxide and other local pollutants that pose a threat to human health, despite representing a much smaller percentage of the automotive fleet. Whenever an older car subject to weaker tailpipe standards is retired and someone buys a new car, not only is it good for the economy, it also helps to clean the air.

But when those new cars are more expensive, Americans slow their purchases. According to Kelley Blue Book, the average price of a new electric vehicle is still more than \$15,000 higher than the average combustion engine car, so at least in the near term, the Environmental Protection Agency's new rule will materially raise the prices of new cars, slow "fleet turnover," and make the air around us dirtier and less safe.

The Biden EPA claims that EV prices will come down rapidly in the coming years, but experience does not always support that: For example, Ford [announced](#) last summer it was raising prices on its F-150 Lightning series between \$6,000 to \$8,500, an increase of about 15 percent per vehicle. The Biden administration proposes to address the higher cost of EVs by offering subsidies to consumers, such as the tax credit of up to \$7,500 per vehicle contained in the Inflation Reduction Act. (The credit is subject to price caps on the cars and income caps on the buyers.) The entire basket of climate

subsidies in the law comes at the cost to taxpayers of \$370 billion over 10 years, yet even this amount is not enough to cover the higher sticker prices of EVs. The new rule will effectively try to shove electric vehicles down the throats of the public at a faster rate than it has shown a willingness to swallow them.

The proposed rule also assumes that Detroit can make these vehicles at this scale — and that the United States would be stronger if it could. Yet, neither is certain: We do not have enough domestic production, or even reliable sources, of the minerals needed to produce the required amounts of electric vehicles, batteries or renewable power that will be required to charge all the new EVs.

As Daniel Yergin, vice chairman of S&P Global, recently [pointed out](#) in the Wall Street Journal, meeting Biden's climate goals will require vast quantities of copper (of which 40 percent is mined in Peru and Chile, and 47 percent is smelted in China), lithium (of which 60 percent is processed in China) and cobalt (of which 70 percent is produced in the Democratic Republic of Congo). By giving unreliable sources and competitors significant leverage over the U.S. automobile industry, this rule will make America less secure.

Finally, the rule rests on dubious legal authority. The Clean Air Act does not specifically regulate carbon dioxide, nor does it give the EPA the authority to require that automakers sell a specific number of EVs. And the Biden administration did not have the votes to pass such a sweeping EV mandate in Congress — even when Democrats controlled both houses. But by setting such stringent fleetwide carbon dioxide emissions requirements in such a tight time frame, the EPA is effectively forcing automakers to radically ramp up EV production as the only way to comply.

This forced remaking of the U.S. automotive industry may not stand up in court, just as the Obama and Biden teams' attempted remaking of the U.S. electric utility industry did not. To quote the Supreme Court's majority opinion in [that matter](#) (*West Virginia v. EPA*), this may be a case of the EPA trying "to adopt a regulatory program that Congress had conspicuously declined to enact itself."

The administration will claim that the rule merely sets an ambitious standard for the fuel efficiency of the entire fleet in a given year. But the EPA's own [projections estimated](#) that 67 percent of new light duty vehicles sold in 2032 — nine years away — would be electric under the proposed rule. By comparison, EVs made up just 5.8 percent of new car sales in the United States last year.

One lesson of the 1990 Clean Air Act — whose [benefits far exceeded its costs](#) — is that it largely let the market, aided by technological innovation, come up with the most efficient ways to reduce emissions as required by law. This new rule would cast that measured approach aside, put the economy and national security at risk, and pile new costs on the American consumer.

The stakes for workers in how policymakers manage the coming shift to all-electric vehicles

Report • By [Jim Barrett](#) and [Josh Bivens](#) • September 22, 2021

Executive summary

Rapid technological change, new market dynamics, and global action to mitigate climate change is driving a historic shift toward electric vehicles (EVs) in the automotive sector. Although hybrid electric vehicles have been part of the U.S. vehicle fleet for more than two decades, and some mass-market EVs have been available for over a decade, battery electric vehicles (BEVs), which are powered exclusively by a battery and an electric motor, currently make up a small part of U.S. auto sales. And the batteries and other drivetrain components in BEVs are largely made by non-U.S. suppliers. The coming shift toward BEVs is a transformational change to the industry that is by now inevitable.

Given that this shift is coming, the most important question for policymakers is how the shift will be managed. Smart policy can transform this industry upheaval into a new beginning for U.S. producers and the rebuilding of a foundation for good jobs. If instead policy remains on autopilot through the upcoming transformation, the shift will instead reduce U.S. employment and further batter job quality in the auto sector. The policy actions needed to

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boost job quality and employment in the auto sector in coming years are not radical. Instead, they are commonsense measures like ensuring that any taxpayer subsidies or rebates to incentivize auto purchases come attached with specific requirements on labor standards in the industry, and with measures to boost investment in domestic auto capacity of U.S. producers and suppliers. If policymakers pass such commonsense measures, the U.S. can regain leadership in auto production in coming decades, and the benefits of this leadership will accrue to workers in the industry.

This report lays out the stakes involved. We report on the likely employment and job-quality implications of a large-scale shift to BEVs under various scenarios that are shaped by policy. By policy, we refer to measures to strengthen U.S. leadership in BEV production, including providing manufacturing incentives to onshore investments, enhancing the share of BEV drivetrain components that are produced domestically, securing and strengthening advanced manufacturing capacity, and crafting better trade agreements with more reliable enforcement measures.

We find that if this shift to BEVs is done without any policy efforts to shore up U.S. leadership in BEV production or to enhance job quality and equitable access to good jobs, then this sector will see employment decline and job quality continue a downward march. But if the shift to BEVs is accompanied by strategic investments in manufacturing and job quality in the U.S. auto sector, then the number and quality of jobs can rise together with BEV production. More specifically, the key findings are:

- Employment in the U.S. auto sector could rise by over 150,000 jobs in 2030 if:
 - Battery electric vehicles rise to 50% of domestic sales of autos in 2030 and
 - Due to smart policy measures, an increase in U.S. production of electric vehicle powertrain components brings U.S. manufacturers' share of the EV powertrain market up to their share of the market of internal combustion engine (ICE) powertrains for today's gas-powered cars, and the U.S.-assembled share of the overall vehicle market increases by 10 percentage points (to 60%).
- Interim production of plug-in hybrid electric vehicles (PHEVs) alongside BEVs could significantly ameliorate sources of downward pressure on jobs as BEV penetration expands.
- Due to manufacturing policy inaction, a rise in BEVs to 50% of domestic auto sales by 2030 could see losses of roughly 75,000 jobs by 2030. These losses would stem from policy failures that stunted investment in domestic capacity of U.S. producers to build the batteries and drivetrains of BEVs, and from a failure to regain market share in overall vehicle sales.
 - Should the U.S. fail to act on both EV deployment and manufacturing, fall further behind other nations as an EV market and location for EV production investment, and lose further market share, job losses could be even greater.
- For the auto sector to continue providing good jobs for U.S. workers, strong labor standards—including affirmative efforts to encourage unionization—will be needed.

Wages in the auto sector continue to be higher than in the rest of the economy, but this relative pay premium is driven by the unionized segment of the sector, and the unionization rate in autos has declined in recent decades. To ensure that U.S.-based producers maintain the technological leadership that will see auto assembly and parts production remain in the U.S., policy measures to encourage investment in all segments of the auto sector (including BEVs and PHEVs) will also be needed.

- Black workers, and workers with less than a bachelor's degree, are likely to have the most to gain from policy action to boost U.S. market share in electric vehicle production—and the most to lose from inaction. That is because Black workers and workers without a four-year college degree make up a disproportionate share of auto parts and assembly employment. Concretely, Black workers account for 12.5% of workers economywide, but 16.6% of workers in the auto sector, while workers without a four-year degree account for 62.2% of workers economywide but 74.6% in the auto sector.

The jobs embedded in the U.S. automobile supply chain once provided a key foundation for middle-class growth and prosperity. A cascade of poor policy decisions has eroded employment and job quality in this sector and this has helped to degrade labor standards across U.S. manufacturing and throughout the overall economy (Cutcher-Gershenfeld, Brooks, and Mulloy 2015). The industry transformation coming due to the widespread adoption of BEVs provides an opportunity to reverse these trends. The transformations necessary to ensure that this shift to BEVs supports U.S. employment and job quality—investment in advanced technology production and strengthening supply chains—will redound widely throughout manufacturing and aid growth in other sectors as well. The shift to BEVs is a key part of mitigating the dire consequences of global climate change, and the more this shift is supported by complementary policies and has clear benefits for workers' job quality and economic security, the more useful it will be as a model for transforming other key economic sectors in ways necessary to combat climate change and ensure prosperous, fair, and equitable outcomes for working people.

Potential employment impacts of a shift to EVs: Policy will matter greatly

This report summarizes the results of an analysis aimed at estimating the potential impacts of increased adoption of electric vehicle (EV) technology on employment in U.S. auto and component manufacturing sectors. Our analysis focuses on how three factors in the transition impact employment in the manufacturing sector: (1) the portion of the fleet that is made up of traditional gas-powered vehicles with internal combustion engines (ICEs) only, battery electric vehicles (BEVs) powered solely by a battery and an electric motor, and plug-in hybrid electric vehicles (PHEVs), which are powered by a battery and an electric motor but also include a backup ICE; (2) the domestic content of the EV powertrains that are installed in both PHEVs and BEVs relative to the domestic content of ICEs; and (3) the share of the domestic car market produced by auto manufacturers in the U.S.

In contrast with other studies (Hibbard and Darling 2021; Goldman School 2021) that look at the economywide impacts of increased BEV deployment, this study focuses more narrowly on the impacts on employment in the auto assembly and auto parts sectors. Given the importance of these sectors to the broader economy and the health of hundreds of U.S. communities, this “narrow” focus—which we label the “auto sector” in tables and figures—does not imply outcomes are of limited importance.

We find substantial potential challenges and opportunities related to increased EV deployment for workers in the auto manufacturing and related sectors. Critically, if the coming shift toward BEVs progresses with current rates of imported EV powertrain parts and domestic auto market share, significant numbers of well-paying manufacturing jobs in the auto sector will be at risk. Very roughly, the current share of BEV powertrain components produced in the U.S. is just under 45%, while for ICE powertrains it is closer to 75% (authors’ analysis from IMPLAN). Conversely, if the U.S. develops stronger domestic industries in key EV supply areas such as battery production, and adds to domestic manufacturers’ market share, there is the potential for significant growth in auto-sector employment and improvements in job quality.

Our analysis models the impacts of increased penetration of both BEVs and PHEVs on auto-sector employment. Modeling the employment implications of manufacturing BEVs and PHEVs at scale is difficult because neither technology has achieved a significant level of penetration in either the car or the light-duty truck and sport utility vehicle (LDT/SUV) market segment.

To overcome this challenge, we adapted a model of the existing auto industry to create models of domestic BEV and PHEV manufacturing at scale. To model BEVs, we removed purchases of ICE drivetrain components from the supply chain of the existing input-output model and replaced them with EV drivetrain parts. Based on public comments from auto industry leaders regarding the fewer hours needed to assemble EV drivetrains, we further modified the existing auto-sector model by reducing labor requirements in auto assembly by 30% per vehicle (Hackett 2017; Vellequette 2019). To model PHEVs, we started with the existing ICE manufacturing model and added EV powertrain purchases equivalent to 25% of the BEV labor requirement for the class of vehicle (car or LDT/SUV) to reflect PHEV powertrain labor requirements. Additionally, we increased the direct labor associated with PHEV assembly by 20% above their ICE equivalents to reflect the increased assembly costs associated with the more complex powertrain (Harbour Consulting 2007).

We conducted our analysis using the IMPLAN input-output model (IMPLAN 2019). Like other input-output models, IMPLAN contains detailed interindustry relationships that indicate how much of various inputs are required to create a certain amount of a given output. In this case, for example, the IMPLAN model shows how an increase in auto-sector output increases demand for intermediate goods and services such as glass, steel, rubber, advertising, etc. IMPLAN also maintains data that indicate how much labor is required to produce a given amount of auto-sector output (direct jobs) as well as the labor associated with the supply chain (indirect jobs) and the economywide employment that is created when auto-sector and supply-chain employees spend their income (induced jobs).

Like other input-output models, IMPLAN abstracts from dynamic impacts, such as how changes in the price of cars and trucks might change total demand for cars or the price of inputs. To hold these influences largely constant and to abstract from other exogenous factors such as changes in overall economic growth, potential changes in raw material costs, and future gasoline prices, we compared employment in the auto industry of 2019 with employment under various EV market penetration scenarios, assuming identical overall domestic market size and cost structure. That is, rather than providing a comparison of *today's* auto sector against *potential future* scenarios, our analysis essentially compares employment in today's auto sector against estimates of what employment would be if EVs represented various shares of today's auto market. As such, our analysis isolates the impact of the different manufacturing requirements of EVs from exogenous factors such as those identified above.¹ Additionally, we analyze a total domestic auto market based on the average combined light-duty fleet sales between 2015 and 2019.

Modeling different scenarios for the rise of EVs

Our analysis examines various scenarios of BEV and PHEV penetration in the new light-duty vehicle fleet (cars, SUVs, and light-duty trucks). Because we anticipate a long-term trend toward BEVs, we consider PHEVs in a limited context only, with a maximum market share of 25% in one of our scenarios to represent a near-term option in the shift away from ICEs.

In addition to various penetration scenarios, we also examine the impact of changes in the domestic content of EV powertrain parts and changes in the share of domestic auto demand met by domestic automakers.

Our first alternative scenario assesses the impacts if U.S. production of EV powertrain components (largely batteries and battery packs) could achieve the same domestic content that ICE powertrain components currently have. Today, the U.S. has much more limited domestic capacity to produce EV powertrain components than it does in engines and transmissions, which are largely domestically produced. Hence, modeling the effect of large-scale introduction of electric vehicles leads to fewer domestic jobs supported by these vehicles, because more of the powertrain parts are supplied by foreign producers. If smarter policy leads to an increase in U.S. capacity to produce EV powertrain components, then the negative employment impact of a large-scale introduction of BEVs is greatly mitigated.

Our next set of alternative scenarios simply examines the employment implications of a 10-percentage-point increase or decrease in overall domestic market share of automobiles. Obviously, an increase in domestic market share leads to more domestic employment and a reduction in this market share leads to lower domestic employment. It is worth noting that a 10-percentage-point increase in U.S. market share for these types of

vehicle sales should not be seen as an unrealistic goal. Over the past decade, the share of U.S. vehicle sales produced in the U.S. has varied between 44% and 56%.² We model a 10-percentage-point gain from 50% in the base model—to a 60% market share.

These alternative scenarios regarding the extent of domestic EV powertrain production and the overall domestic market share are highly conditional on the acts of policymakers in supporting—or failing to support—the growth of the future U.S. auto sector.

As mentioned above, this analysis is narrowly focused on the impacts of increased EV technology deployment on employment in car and LDT/SUV auto and parts manufacturing. We do not consider the impact of electric vehicle technologies on heavy-duty vehicle manufacturing, the impact of BEV adoption on auto maintenance and repair industries, the potential impact on retail sales of consumer goods at fueling stations, or the impact on the broader economy due to changes in oil and electricity consumption associated with BEV penetration. We make no effort to predict the overall size of the domestic auto market, or the impact of specific subsidies for BEV purchasing or manufacturing. Finally, we did not model any of the infrastructure requirements likely necessary with an increasing BEV fleet, such as public charging stations and upgrades to electricity transmission and distribution systems. Our analysis does not assess the costs or benefits of any particular policy approach to achieve the various outcomes we analyze, opting instead to look only at the economic implications of the outcomes themselves.

Results: Employment impacts under different scenarios

The results of our analysis are represented in the charts below. We break our results into two categories, Assembly and Parts. Assembly represents employment at auto-manufacturing plants themselves, while Parts represents employment in the auto-sector supply chain. For this analysis, we include in the Parts category only those supply chain elements that become a physical part of the autos themselves, including things like tires, glass, and electronics, but excluding things like expenditures on real estate, advertising, and machinery.

The employment impact of growth in electric vehicle market share under different scenarios

Figure A shows the potential job changes for a range of scenarios regarding the growth of market share of electric vehicles—namely battery electric vehicles—by 2030. The first scenario assumes all-electric vehicles (BEVs) account for 30% of the auto market by 2030, with traditional gas-powered (internal combustion engine powered) vehicles retaining 70% of the market. The second scenario assumes a 50/50 split between BEVs and ICEs. The third scenario assumes that ICEs retain 50% of the market but the remaining 50% is split between BEVs and hybrids (PHEVs). The fourth scenario assumes that ICEs retain 50% of

the market, BEVs account for 40%, and PHEVs account for the remaining 10%.

These scenarios assume no change in the share of electric vehicle powertrain components that are manufactured in the U.S. and no change in the U.S. share of the global auto market. Specifically, under our model, the domestic content of EV powertrain components are set to the IMPLAN default values for those commodities and also assume a 50% domestic manufacturer market share for both cars and light trucks/SUVs. In short, these estimates represent job changes under differing penetrations of EVs in a business-as-usual scenario where nothing is done to increase domestic production of EV powertrains or to improve domestic producers' overall share in the auto market.

In the first scenario, with 30% BEV penetration and 70% ICE market share, about 20,000 assembly jobs are lost and almost 25,000 parts jobs are lost. Assembly jobs are lost because BEV assembly is less complex and requires fewer person-hours than ICE assembly. The lost parts jobs are mostly due to the fact that the U.S. currently lags Europe and Asia in domestic battery and battery cell and materials production capacity, resulting in lost domestic employment in powertrains.

In the second scenario, with 50% BEV and 50% ICE market shares, the losses proportionately scale up relative to the first scenario. In the third scenario, with BEVs accounting for 25% of the market, PHEVs accounting for 25% of the market, and ICE retaining 50% of market share, the job losses for both assembly and parts are substantially reduced. PHEVs actually require more assembly jobs and slightly more parts than even ICE vehicles, hence the very substantial reduction in assembly jobs lost relative to the second scenario. PHEVs also require an ICE-type powertrain, so more of the powertrain is supplied by domestic producers and hence the job losses in parts is also blunted relative to other scenarios.

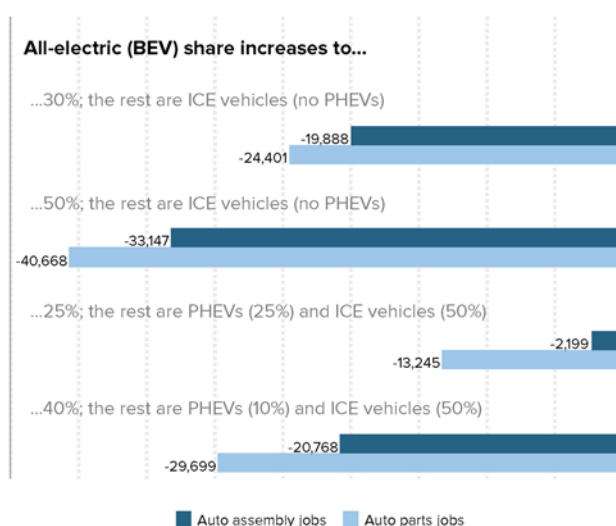
In the fourth scenario, with lower PHEV penetration than the third scenario (10% instead of 25%), the job losses from 40% penetration of BEVs is again blunted, but less so—over 50,000 jobs are lost, with nearly 30,000 of these in parts.

Figure B highlights how important one aspect of policy will be in shaping the job implications of a large-scale shift to electric vehicles. It shows the same scenarios as Figure A regarding market penetration by auto type, but changes the assumption regarding domestic content of EV powertrains. If policy supports increasing domestic production of EV powertrain components to levels comparable with domestic content of ICE powertrains, then a huge share of job losses embedded in the scenarios of Figure A can be avoided. All of these job-loss reductions are accomplished by reducing job losses in auto parts. In the first scenario, job losses that reached nearly 25,000 under the business-as-usual assumptions of Figure A would be reduced to roughly 1,500 if domestic content in EV powertrains could match current domestic content in ICE powertrains. Under the third scenario (the one that includes a 50% market share for ICEs but with BEVs and PHEVs each satisfying 25% of the market), there would be no job losses at all in parts production: Again, the parts requirements of PHEVs are actually slightly greater than even for ICEs, so the boost to parts employment stemming from greater parts use of PHEVs

Figure A

Without manufacturing policy action, growth in the electric vehicle share of the auto market leads to job losses; inclusion of plug-in hybrids mitigates some losses

Change in U.S. auto jobs in 2030 if the total number of cars made stays the same but the share that are battery electric vehicles rises



Notes: Today vehicles powered exclusively by a battery and an electric motor (battery electric vehicles, or BEVs) make up a very small share of the U.S. light-duty vehicle market (cars, vans, SUVs, and pickup trucks). Most vehicles are still conventional gas/diesel-powered (i.e., powered by internal combustion engines, or ICEs), and the rest are plug-in hybrid electric vehicles, or PHEVs, which are vehicles powered by a battery and an electric motor in addition to an ICE. The figure shows the job effects if the total number of cars produced in the U.S. stays the same but there is a rise in the shares that are BEVs and PHEVs. All other factors remain the same (e.g., the U.S. share of all autos produced remains the same, as does the share of a particular type of vehicle's drivetrain that is made up of domestic content).

Source: Authors' analysis of scenarios described in the text, from results estimated using the IMPLAN (2019) input-output model.

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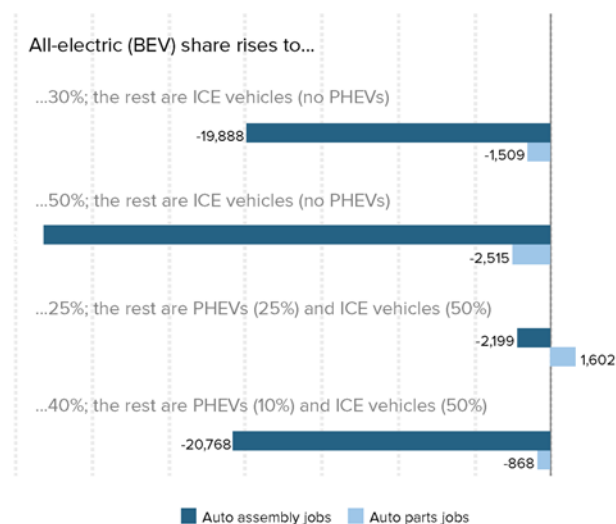
would very slightly outstrip the small parts losses due to the shift to BEVs.

Figure C shows that improving domestic capacity in powertrain components for BEVs and boosting the market share of U.S.-based producers will lead to job gains in the auto sector

Figure B

Onshoring and expanding electric vehicle powertrain components production in the U.S. would greatly stem auto parts job losses from growth in the electric vehicle share of the auto market

Change in U.S. auto jobs in 2030 if the EV market share rises and the U.S.-produced share of EV powertrain components rises to equal that of conventional vehicle powertrains



Notes: Today vehicles powered exclusively by a battery and an electric motor (battery electric vehicles, or BEVs) make up a very small share of the U.S. light-duty vehicle market (cars, vans, SUVs, and pickup trucks). Most vehicles are still conventional gas/diesel-powered (i.e., powered by internal combustion engines, or ICEs), and the rest are plug-in hybrid electric vehicles (PHEVs), which are vehicles powered by a battery and an electric motor in addition to an ICE. The figure shows the job effects if the total number of cars produced in the U.S. stays the same but there is a rise in the shares that are BEVs and PHEVs, and if an increase in U.S. production of electric vehicle (EV) powertrain components brings U.S. manufacturers' share of the EV powertrain market up to their share of the ICE powertrain market.

Source: Authors' analysis of scenarios described in the text, from results estimated using the IMPLAN (2019) input-output model.

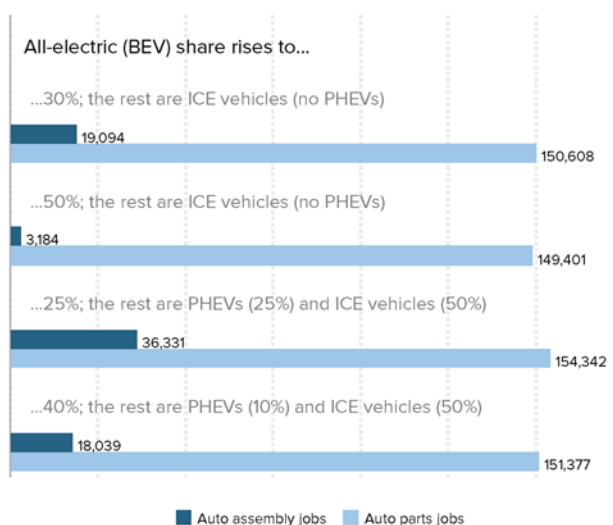
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regardless of the extent of BEV penetration in 2030. In short, what will determine how much employment in the U.S. auto sector will grow is not the growth of BEVs—which is inevitable at this point. Instead, it is the policy response.

Figure C

Onshoring power train production and boosting domestic share of vehicles sold would lead to large job gains

Change in U.S. auto jobs under various BEV penetration scenarios, if U.S. EV powertrain component production matched ICE average and the share of domestically produced vehicles sold in the U.S. increased by 10 percentage points



Note: The figure shows the job effects if the total number of cars produced in the U.S. stays the same but there is a rise in the shares that are BEVs (battery electric vehicles) and PHEVs (plug-in hybrid electric vehicles), an increase in U.S. production of electric vehicle (EV) powertrain components brings U.S. manufacturers' share of the EV powertrain market up to their share of the ICE (internal combustion engine) powertrain market, and there is a 10-percentage-point increase in the share of all vehicles sold in the U.S. produced by U.S.-based domestic manufacturers.

Source: Authors' analysis of scenarios described in the text, from results estimated using the IMPLAN (2019) input-output model.

Economic Policy Institute

Figure D shows the importance of policies by presenting a range of outcomes depending on market share and policy assumptions. Each scenario in Figure D assumes a 50% penetration of ICEs. The base scenario assumes that the other 50% of the market is satisfied by BEVs and no policy changes affect the status quo in terms of market share of all vehicles and powertrain components. Under this scenario, which is the same as the

second scenario in Figure A, there is a loss of nearly 75,000 jobs. From here, the influence of changing other assumptions is examined. The “hybrid” scenario starts from the base of 50% ICEs but then assumes that 25% of the market is satisfied by PHEVs (as is one of the scenarios examined in Figure A), with the remaining 25% satisfied by BEVs.

The “equivalent domestic content” scenario starts from the base but then assumes that the domestic market share of EV powertrains reaches the current domestic market share of ICE powertrains (as is one of the scenarios examined in Figure B). The “+10 ppt. market share” scenario starts from the base but then assumes that domestic auto producers boost their share of overall vehicle sales by 10 percentage points. The “–10 ppt. market share” scenario starts from the base and assumes a 10-percentage-point decline in domestic auto producers’ share of overall vehicle sales.

The final scenario starts from the base scenario and then assumes *both* that the domestic market share of EV powertrains matches current ICE powertrain production *and* that domestic auto producers boost their share of overall vehicle sales by 10 percentage points.

The results show how dramatically the future market share claimed by the U.S. auto sector—both in parts production and in overall sales—will shape the job-market implications of a shift toward BEVs in the future. For example, a 10-percentage-point across-the-board *increase* or *decline* in domestic auto producers’ share of vehicle sales is the difference between over 100,000 jobs gained or more than 250,000 jobs lost as BEVs are introduced. If a 10-percentage-point increase in overall vehicle sales market share could be matched with domestic competitive parity in producing EV and ICE powertrains, then the introduction of BEVs could lead to job gains exceeding 150,000.

Figure D highlights how powerful it would be for creating good jobs to regain U.S. leadership in auto production—both in powertrain components for BEVs and in regaining previous levels of overall market share.

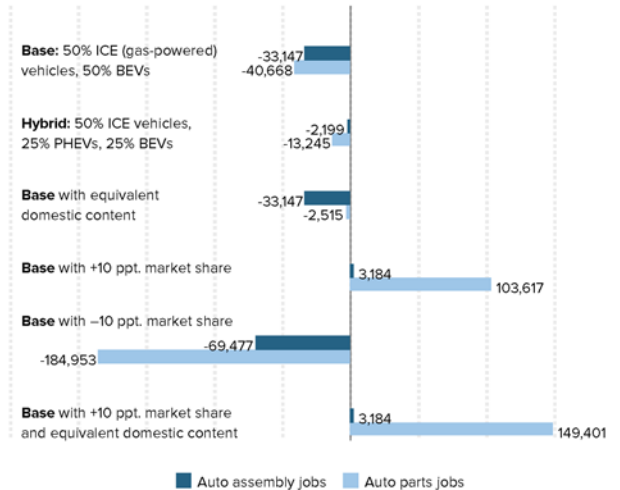
Reviewing the distribution of job gains or losses to understand their implications

Table 1 suggests how the job change estimates from the various scenarios above would affect workers by showing the current demographic makeup of the workforce in the automobile production sector (the workforces of auto assembly and parts), the share that are unionized (i.e., covered by a collective bargaining agreement), and, for those with less than a four-year college degree, their wages. The composition of workers affected by the job changes could of course be affected by policy. For example, at current rates of unionization the jobs created under the smarter policy scenarios implied by Figure D (policies that boost market share overall as well as market share of EV drivetrain production) would be less than 15% unionized. But policy can boost this share significantly if fundamental labor law reforms are enacted and if public funds used to guide the EV transition are contingent upon strong labor standards.

Figure D

Policies that help the U.S. regain leadership in the auto sector will affect job changes associated with growth in the electric vehicle share of the auto market

Change in U.S. auto jobs in 2030 if electric vehicles account for half of the auto market, under various scenarios



Notes: "Equivalent domestic content" means U.S. manufacturers' share of the EV (electric vehicle) powertrain market matches their share of the ICE (internal combustion engine, i.e., gas-powered) powertrain market. BEVs refers to battery electric (all-electric) vehicles. PHEVs refers to plug-in hybrid electric vehicles. A +10 ppt. market share means the domestic share of overall vehicle sales increases by 10 percentage points. A -10 ppt. market share means the domestic share of overall vehicle sales decreases by 10 percentage points.

Source: Authors' analysis of scenarios described in the text, from results estimated using the IMPLAN (2019) input-output model.

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For now, however, as Table 1 shows, the incumbent automobile production workforce skews quite heavily male. Black workers make up a disproportionate share of autoworkers, and autoworkers are less likely to have a four-year college degree than workers overall. Specifically, the overall workforce is 51.8% male and 12.5% Black, and 24.1% have a four-year college degree as their highest level of educational attainment. In the automobile production sector, 74.2% of workers are male, 16.6% are Black, and 17.2% have a four-year college degree but not an advanced degree.

Automobile workers are also heavily concentrated regionally. The seven states of the Upper Midwest³ account for 54.8% of automobile jobs, the 11 states of the South⁴ account for 30.1% of auto jobs, California accounts for 4.5% of auto jobs, and the remaining 32 states (which includes the District of Columbia) account for just 10.6% of these jobs.

Table 1 also highlights the auto sector's high unionization rate and higher wages—at the 10th, median, and 90th percentiles—relative to other sectors of the economy and the workforce overall. In the automobile sector, the share of workers covered by a collective bargaining agreement is 17.0%, compared with 11.8% in the overall workforce, 9.3% in all of manufacturing, and 7.1% in the private sector (not shown in table).⁵ These facts are surely related: The higher wages paid by the automobile sector are particularly striking given the lower share of the auto workforce with a four-year college degree.

Table 2 compares the unionized and nonunionized automobile sectors along many of the same dimensions. The share of women is lower in the unionized sector, 23.6% compared with 26.2% in the nonunionized sector. Strikingly, the share of Black workers is significantly lower in the nonunionized sector, despite the fact that a much larger share of nonunion auto production occurs in the South, a region with a much higher share of Black workers economywide. **Table 3** shows the share of workers by race and ethnicity in each of the four “regions” constructed for this analysis.

It is worth highlighting as well that the job quality of the nonunionized auto sector might be even worse than Table 2 suggests, as there has been a shift in that sector toward hiring from temporary staffing agencies: By 2014, unpublished estimates from the U.S. Census Bureau indicated that roughly 14% of all workers engaged in automobile production were actually hired from temporary staffing agencies (Ruckelshaus and Leberstein 2014). The temp workers would be classified as in the automobile sector in the Current Population Survey (CPS) data used to construct Table 2, but other research has documented that pay for these temp workers is significantly lower than pay for permanent automobile sector workers (even nonunionized workers).

As the tables show, Black workers' share of the unionized automobile production workforce (25.5%) is substantially higher than Black workers' share of the overall workforce in the Upper Midwest (10.5%), while the share of nonunionized automobile production workers who are Black (14.8%) is substantially lower than Black workers' share of the overall workforce in the South (18.9%). This strongly suggests that, given the racial composition of the regional economy, the unionized segment of the auto-production sector has done a much better job of making job opportunities available to Black workers.

As shown in Table 2, wages at the 10th, 50th, and 90th percentiles are significantly higher for workers without a four-year college degree in the unionized automobile sector. The same holds true for the shares of workers covered by employer-provided health insurance and pension plans. In short, the association between higher job quality and unionization is, not surprisingly, strong. **Figure E** highlights this in more detail, with the dark blue line showing how much higher median wages are in the automobile sector than median wages economywide, and the light blue line showing the ratio of unionization rates in the

Table 1

Demographics, wages, and benefits of workers in auto sector, manufacturing, and all industries

	Auto sector	All of manufacturing	Economywide
Gender			
Male	74.2%	70.9%	51.8%
Female	25.8%	29.1%	48.2%
Race/ethnicity			
White, non-Hispanic	65.6%	64.3%	61.9%
Black, non-Hispanic	16.6%	10.3%	12.5%
Hispanic	10.4%	16.9%	17.5%
Asian American Pacific Islander (AAPI)	6.6%	7.5%	7.0%
Other	0.9%	1.0%	1.1%
Union status			
Union	17.0%	9.3%	11.8%
Nonunion	83.0%	90.7%	88.2%
Education			
Less than high school	6.6%	9.2%	8.1%
High school diploma/GED only	37.3%	34.0%	25.9%
Some college	30.7%	26.5%	28.2%
Bachelor's degree	17.2%	21.0%	24.1%
Advanced degree	8.2%	9.3%	13.7%
Wages for workers with less than a four-year college degree			
10th-percentile wage	\$11.85	\$11.14	\$9.62
Median wage	\$18.34	\$18.22	\$15.84
90th-percentile wage	\$32.64	\$33.44	\$32.40
Employer-sponsored benefits			
Health insurance coverage	74.0%	66.8%	52.8%
Pension coverage	47.7%	43.2%	34.0%
Regions			
Upper Midwest	54.8%	28.2%	18.6%
South	30.1%	28.5%	31.2%
California	4.5%	10.6%	11.6%
Other	10.6%	32.7%	38.5%

Notes: Data are for workers ages 16 and older. Wage data are from 2016–2020 and are adjusted to 2020 dollars. Data on employer-sponsored pension and health insurance coverage are from 2015–2019. The xth-percentile wage is the wage at which x% of wage earners earn less and (100–x)% earn more. Self-employed and self-incorporated workers are excluded. The auto sector includes auto assembly and auto parts. Share of union workers is share covered by a collective bargaining agreement. Upper Midwest states are Illinois, Indiana, Michigan, Missouri, Ohio, West Virginia, and Wisconsin. Southern states are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. "Other" are all other states (those not in the Upper Midwest, South, or California region), including the District of Columbia.

Source: EPI analysis of BLS Current Population Survey (CPS) Outgoing Rotation Group (ORG) 2016–2020 pooled data and Current

Table 1
(cont.)

Population Survey (CPS) Annual Social and Economic Supplement (ASEC) 2015–2019 pooled data (EPI 2021).

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automobile sector to unionization rates economywide. The association between these lines is clear: As the auto sector's high union coverage relative to coverage overall erodes rapidly in the 1980s, 1990s, and 2000s, the relative pay advantage of working in the automobile sector declines as well. In the late 1980s, auto workers were nearly three times as likely to be unionized as workers overall and earned roughly 60% higher wages at the median; in 2020, they were only slightly more likely to be unionized and had median wages just 7% higher.

The decline of unionization in the automobile sector was driven by policy failures both within the auto supply chain and throughout the economy. Within the sector, policy failures to help U.S. producers invest and maintain their competitive position in the face of oil price shocks in the 1970s led to lost market share for the unionized automakers once known as the Big Three (General Motors, Ford, and Fiat Chrysler). Poorly structured trade agreements and lack of trade enforcement put further downward pressure on industry employment and job quality. In the broader economy, contractionary macroeconomics policy, failure to keep the U.S. dollar at a competitive level, and an assault on labor standards all spilled over to do great damage to workers in the U.S. auto supply chain (Scott and Glass 2016). These processes should not be allowed to repeat in coming decades as an even larger (albeit potentially better-planned) transformation in the auto sector looms with the introduction of EVs.

Conclusion

U.S. automotive workers have had their economic opportunities and job quality battered for decades by harmful policy decisions. The massive coming shifts in automotive sales toward EVs present new challenges and opportunities for these workers. If policymakers ignore the opportunity to build the sector back stronger, large job losses and further degradation of job quality is the most likely outcome. If instead policymakers help meet this coming transformation with strong investment targeted at boosting the U.S. position in the electric vehicle market and in advanced vehicle technology manufacturing, and if these investments are accompanied by measures aimed at strengthening bargaining power for workers, then employment will expand in the U.S. auto sector and the number of unionized jobs will grow. With a smart policy push, the long downward slide in job quality will reverse at the same time that the U.S. leads in building the vehicles of the future and combating climate change.

Acknowledgments

This report was produced in collaboration with the BlueGreen Alliance, AFL-CIO Industrial Union Council, United Auto Workers, United Steelworkers, and The Greenlining Institute.

Table 2

Demographics, wages, and benefits of workers in the unionized auto sector, nonunion auto sector, overall auto sector, and all industries

	Unionized auto sector	Nonunion auto sector	Overall auto sector	Economywide
Gender				
Male	76.4%	73.8%	74.2%	51.8%
Female	23.6%	26.2%	25.8%	48.2%
Race/ethnicity				
White, non-Hispanic	62.4%	66.3%	65.6%	61.9%
Black, non-Hispanic	25.5%	14.8%	16.6%	12.5%
Hispanic	7.7%	10.9%	10.4%	17.5%
Asian American Pacific Islander (AAPI)	3.1%	7.3%	6.6%	7.0%
Other	1.2%	0.8%	0.9%	1.1%
Education				
Less than high school	5.3%	6.8%	6.6%	8.1%
High school diploma/GED only	42.3%	36.3%	37.3%	25.9%
Some college	41.5%	28.4%	30.7%	28.2%
Bachelor's degree	8.1%	19.0%	17.2%	24.1%
Advanced degree	2.8%	9.3%	8.2%	13.7%
Wages for workers with less than a four-year college degree				
10th-percentile wage	\$13.00	\$11.62	\$11.85	\$9.62
Median wage	\$20.95	\$17.95	\$18.34	\$15.84
90th-percentile wage	\$33.00	\$32.36	\$32.64	\$32.40
Employer-sponsored benefits				
Health insurance coverage	82.4%	73.8%	74.0%	52.8%
Pension coverage	52.9%	47.5%	47.7%	34.0%
Regions				
Upper Midwest	74.9%	50.7%	54.8%	18.6%
South	16.4%	32.9%	30.1%	31.2%
California	2.1%	4.9%	4.5%	11.6%
Other	6.6%	11.4%	10.6%	38.5%

Notes: Data are for workers ages 16 and older. Wage data are from 2016–2020 and are adjusted to 2020 dollars. Data on employer-sponsored pension and health insurance coverage are from 2015–2019. The xth-percentile wage is the wage at which x% of wage earners earn less and (100-x)% earn more. Self-employed and self-incorporated workers are excluded. Unionized workers are those covered by a collective bargaining agreement. Upper Midwest states are Illinois, Indiana, Michigan, Missouri, Ohio, West Virginia, and Wisconsin. Southern states are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. "Other" are all other states (those not in the Upper Midwest, South, or California region), including the District of Columbia.

Source: EPI analysis of BLS Current Population Survey (CPS) Outgoing Rotation Group (ORG) 2016–2020 pooled data and Current Population Survey (CPS) Annual Social and Economic Supplement (ASEC) 2015–2019 pooled data (EPI 2021).

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Luke Tonachel of the Natural Resources Defense Council and Erin Falquier of Chicane

Table 3

Racial and ethnic demographics of workers in the four automaking 'regions'

	Upper Midwest	South	California	Other
<i>White, non-Hispanic</i>	76.9%	56.4%	37.6%	66.5%
<i>Black, non-Hispanic</i>	10.5%	18.9%	5.9%	10.4%
<i>Hispanic</i>	7.9%	19.5%	37.8%	14.4%
<i>Asian American Pacific Islander (AAPI)</i>	3.9%	4.5%	17.8%	7.1%
<i>Other</i>	0.8%	0.8%	0.8%	1.6%

Notes: Data are for workers ages 16 and older. Upper Midwest states are Illinois, Indiana, Michigan, Missouri, Ohio, West Virginia, and Wisconsin. Southern states are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. "Other" are all other states (those not in the Upper Midwest, South, or California region), including the District of Columbia.

Source: EPI analysis of BLS Current Population Survey (CPS) Outgoing Rotation Group (ORG) 2016–2020 pooled data (EPI 2021).

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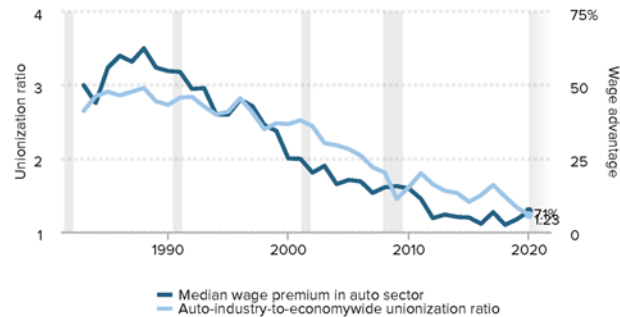
Endnotes

1. This is an important, and we think valuable, aspect of this study. The automobile production sector has seen rapid productivity growth in recent decades and likely will continue to see this going forward—it has benefited from automation as much as any other industrial sector. This rapid automation and productivity growth by itself puts substantial downward pressure on employment levels in the sector. Even if nothing changed with regard to the composition of the auto fleet in coming decades, projections of employment in the sector would likely show nontrivial declines, largely driven by the intersection of rapid productivity growth and slowing consumer demand. Such projections highlight real challenges for autoworkers, but they are not challenges introduced by EVs, and disentangling these substantial effects from those stemming strictly from EVs is a useful exercise.
2. Analysis provided in correspondence by Kristin Dziczek of the Center for Automotive Research (CAR).
3. Upper Midwest states are Illinois, Indiana, Michigan, Missouri, Ohio, West Virginia, and Wisconsin.
4. Southern states are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.
5. EPI analysis of BLS Current Population Survey (CPS) Outgoing Rotation Group (ORG) 2016–2020 pooled data (EPI 2021).

Figure E

Pay advantage for autoworkers declines as unionization falls

Ratio of auto industry unionization rate to economywide unionization rate, and percent pay advantage for the median auto worker over the median worker economywide, 1983–2020



Notes: Wage data are adjusted to 2020 dollars. Data are for employed workers ages 16 and older. Self-employed, self-incorporated workers are excluded. The auto industry includes auto assembly and auto parts. The unionization rate is the share of workers covered by a collective bargaining agreement.

Source: EPI analysis of BLS Current Population Survey (CPS) Outgoing Rotation Group (ORG) 1983–2020 microdata (EPI 2021).

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U.S. Electric Vehicle Manufacturing Investments and Jobs

Characterizing the Impacts of the
Inflation Reduction Act after 6 Months
March 2023



This report summarizes the significant investments in the electric vehicle (EV) ecosystem that have been announced over the past 8 years. This includes announced investments in EV, EV battery, and battery component manufacturing.

Announced EV, EV Battery, and Battery Component Investment & Employment 2015 - 2023

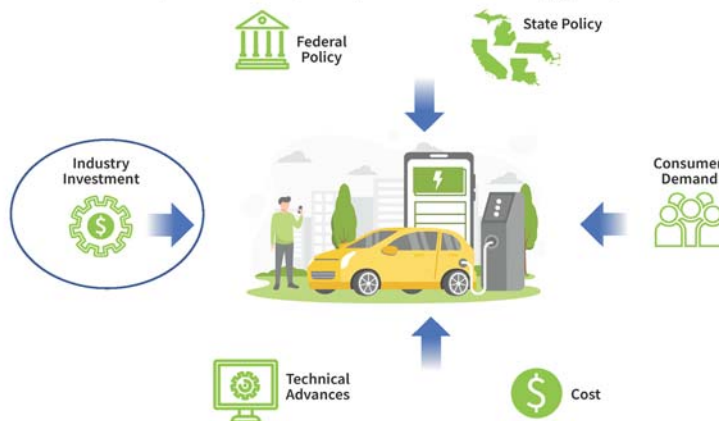
Manufacturing	Investment	Announced New Jobs*
Electric passenger vehicles	\$31.4 billion	55,800
Electric vans, buses and trucks	\$9.0 billion	17,400
EV batteries	\$65.3 billion	61,700
EV battery components	\$14.4 billion	8,100
Total	\$120.1 billion	143,000

** Some of these new jobs already exist for facilities that are operating, others are based on company announcements and have yet to be created.*

Electric Vehicle Policy Landscape

This investment has been catalyzed by recent federal legislation.

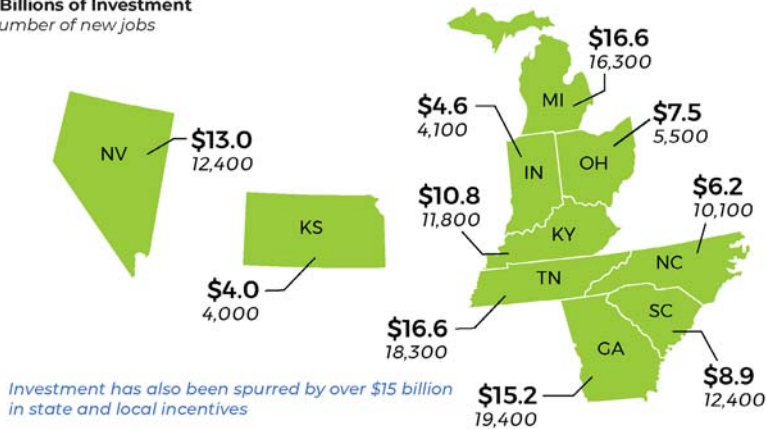
- ▶ Bipartisan Infrastructure Law (BIL) November 2021
 - ▶ Over \$100 billion in spending supporting EVs and clean energy policy
- ▶ Inflation Reduction Act (IRA) August 2022
 - ▶ \$369 billion in spending on climate and energy policy





86% of Announced Investment is in 10 States

\$ Billions of Investment
Number of new jobs



State	Total Announced Investment (\$ billions)
Michigan	16.6
Tennessee	16.6
Georgia	15.2
Nevada	13.0
Kentucky	10.8
South Carolina	8.9
Ohio	7.5
North Carolina	6.2
Indiana	4.6
Kansas	4.0
Arizona	3.7
California	2.5
Alabama	2.4
Texas	2.2
Illinois	1.3
Other	4.6
Total	120.1



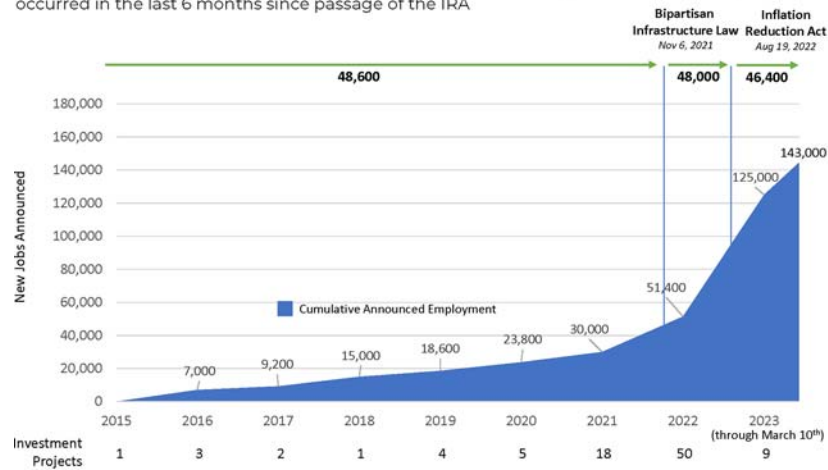
- ▶ 93 manufacturing investments announced in the past 8 years
- ▶ Over \$120 billion in private investment announced
- ▶ These investments will result in 143,000 new jobs





New EV Job Announcements Accelerated by National Policy

46,400 announced jobs, representing approximately 32% of all EV job announcements, have occurred in the last 6 months since passage of the IRA



State	Announced New Jobs
Georgia	19,400
Tennessee	18,300
Michigan	16,300
Nevada	12,400
South Carolina	12,400
Kentucky	11,800
North Carolina	10,100
Arizona	7,600
Illinois	6,600
Ohio	5,500
Texas	4,600
Indiana	4,100
Kansas	4,000
California	2,500
Alabama	1,500
Other	6,000
Total	143,000

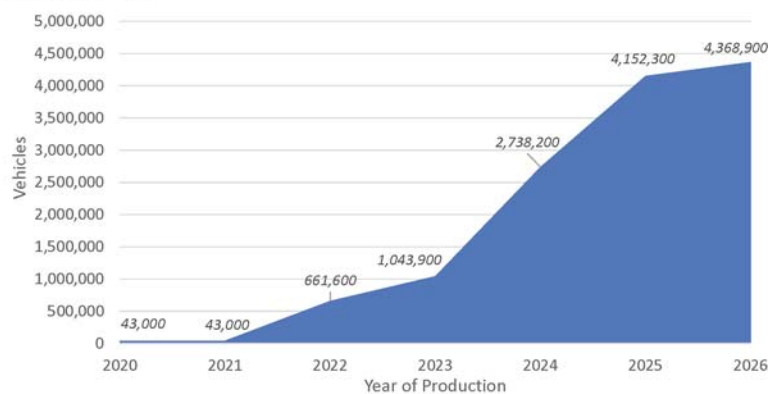
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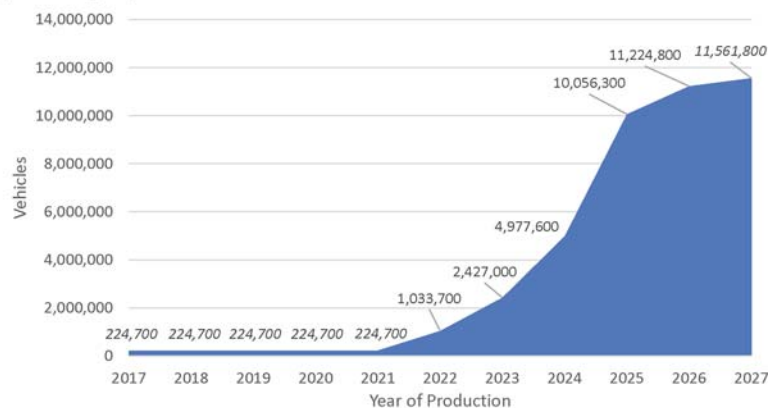
Total EV Manufacturing Capacity

U.S. EV manufacturing facilities will be capable of producing approximately 4.3 million new passenger vehicles each year in 2026, which represents approximately 33 percent of all new vehicles sold in 2022.



Battery Manufacturing Capacity

In 2026, U.S. battery manufacturing facilities will be capable of producing batteries sufficient to supply up to 11.2 million new passenger vehicles each year, which represents approximately 84 percent of new vehicles sold in 2022.





Key Takeaways

- ▶ **Investment.** Over the last 8 years, manufacturers have announced over \$120 billion in concrete investment in U.S. EV and EV battery manufacturing facilities. Federal policies have dramatically expanded and accelerated these investments: 42 percent of announced EV investments have occurred in the last 6 months since passage of the IRA and 73 percent have occurred in the last 15 months since passage of the Bipartisan Infrastructure Law.
- ▶ **Jobs.** Supported by these investments, over the last 8 years, manufacturers have announced over 143,000 new U.S. EV-related jobs. Federal investments and incentives that are specifically designed to onshore the EV manufacturing supply chain have likewise substantially expanded and accelerated new job announcements. Of all the new EV jobs announced since 2015, 32 percent are represented by announcements occurring in the last six months (since the passage of the IRA) and 66 percent are represented by announcements occurring in the last 15 months since the passage of the BIL.
- ▶ **States.** 10 states account for 86 percent of announced EV manufacturing investments. Michigan, Georgia, and Tennessee each individually have more than \$15 billion in investments supporting more than 15,000 new jobs in the state.
- ▶ **Production Capacity.** In 2026, U.S. EV manufacturing facilities will be capable of producing approximately 4.3 million new passenger vehicles annually (which represents 33 percent of new vehicles sold in 2022). In 2026, U.S. battery manufacturing facilities will be capable of producing batteries sufficient to supply 11.2 million new passenger vehicles each year (which represents 84 percent of new vehicles sold in 2022).
- ▶ **Market Dynamism, Additional Policies.** U.S. investments, jobs, and production capacity will likely continue to grow in response to strong federal investments and incentives. Each new investment announcement represents an opportunity to set a strong standard for what high-quality, community-sustaining jobs in the clean economy can look like. Policymakers and granting agency staff must work with employers, labor, and community-based organizations to maximize the benefits of onshoring the EV manufacturing supply chain for the workers who comprise it, and for the communities where new investments are being made.

Methodology

This report summarizes private investments made or announced within the past 8 years in the U.S. electric vehicle (EV) ecosphere. This includes investments in the manufacturing of EVs, EV batteries, and EV battery components. The research built off previous work contained in the Environmental Defense Fund's (EDF's) April 2022 document, [Electric Vehicle Market Update: Manufacturer Commitments & Public Policy Initiatives Supporting Electric Mobility in the U.S. & Worldwide](#). The research began by compiling additional information on the 28 investment projects identified in Figure 9 of the EDF document and the subsequent table identifying "Announced Electric Vehicle Manufacturing Plant Expansions and Future Plans."



The research team developed a database with information on these projects found in on-line announcements put out by the investors, state and local governments, industry publications and local media, to capture the following data for each project:

- ▶ Company and nationality
- ▶ Investment type (*EV assembly plant, Battery manufacturing plant, Battery component plant*)
- ▶ Location (*City, State*)
- ▶ Announced investment value (*\$ billions*)
- ▶ Facility production capacity (*vehicles/year, Gigawatt-hours/year, tons/year*)
- ▶ Announced facility employment (*number of jobs*)
- ▶ Announcement Date
- ▶ Schedule (*Construction Begins, Production Begins*)
- ▶ Local Incentives value (*\$ billions*) and description
- ▶ Federal Incentives value (*\$ billions*) and description

Through additional on-line searches, the research team identified 65 additional investments that were either announced or entered into production since the publication of the April 2022 EDF report. The data set only includes projects with announced investment levels and known construction start or completion dates. If an investment was announced, but no corroborating information could be found that it had actually entered construction or operation, it was excluded from the data set. The research also included a review of the 21 projects selected for a combined total of \$2.8 billion in [Battery Materials Processing and Manufacturing & Recycling Grants](#) by the U.S. Department of Energy in October 2022.

In all, the research identified 16 projects announced between 2015 and 2020; 18 projects announced in 2021; 50 projects in 2022; and 9 projects through March 10, 2023.

While investment levels are known for all projects, not all other parameters of interest were available for all projects. The research team developed tailored average values for each facility type – EV, EV battery and battery component – for three parameters: employment, capacity, and construction time. In cases where jobs or production capacity data is unknown for a specific project, the research team estimated values for these parameters based on the announced investment value, and averages (production per \$ billion investment and jobs per \$ billion investment) for all announced similar projects for which this data is available. Given the variety of different measures used to quantify the production of battery component plants, this information was noted, but not included in the quantitative analysis.

Similarly, for projects for which production start date is unknown, the project team estimated a production start date based on the construction start date and the average construction duration for similar projects for which both construction start and production start dates are known. The total values for cumulative production and jobs by year shown in this report include these estimates. Of the cumulative 143,000 EV ecosystem jobs announced between 2015 and March 10, 2023, 75% are announced jobs, with the remainder estimated jobs.

Of the 4.4 million annual EV manufacturing capacity expected online in 2026, 62% is announced capacity and the remainder is estimated capacity. Of the 11.5 million annual EV battery manufacturing capacity expected online in 2026, 82% is announced capacity and the remainder is estimated capacity.

It should be noted that the battery manufacturing capacity is reported in terms of the approximate number of light duty vehicles that the batteries could power, for consistency. Battery manufacturing capacity values were available in gigawatt-hours for most of the projects, which were converted using a factor of 89 kWh/EV. This is the average of the values used by the U.S. Department of Energy Office of Energy Efficiency, Vehicle Technologies Office (77 – 100 kWh/EV) to estimate 2030 North American EV battery production capacity in Fact of the Week #1271, published January 2, 2023. This figure is larger than the current size of most EV batteries, so the resulting battery production figures can be considered conservative.





IRA EV Tax Credits: Requirements for Domestic Manufacturing

By Owen Minott, Helen Nguyen

Feb 24, 2023

SHARE



THE BRIEF

The Inflation Reduction Act changed the rules for the electric vehicle tax credit. It set strict requirements on which vehicles are eligible to encourage automakers to shift manufacturing operations to North America.

Automakers success at rapidly adapting their operations to meet the new requirements will determine how many EVs are eligible for tax credits. This could shape the effectiveness of the tax credits as an incentive to encourage electric vehicle ownership.

This blog outlines the new requirements, the status of their implementation, and the scope of the challenge automakers face to adapt their supply chains to make their electric vehicle models eligible for tax credits.

The Inflation Reduction Act (IRA) included a \$7,500 consumer tax credit for electric vehicle (EV) purchases, renewing and modifying the existing tax credit. EV sales substantially increased their market share in recent years, rising from 3.2% of all vehicles sold in the U.S. in 2021 to 5.8% in 2022. The Biden administration hopes to continue that trend by setting a target to make zero-emissions vehicles half of all new vehicles sold in 2030. The administration views tax credits as an important tool to encourage EV purchases because, while

buyers save on the cost of fuel, EVs typically cost more than non-electric vehicles due to the high cost of producing EV batteries.

IRA EV Tax Credit Provisions

Consumers are eligible for the tax credit if they report adjusted gross incomes of up to:

- \$150,000 for individuals
- \$225,000 for heads of households
- \$300,000 for joint filers



The new credit eliminates the cap for how many EVs a manufacturer can sell to still qualify, and now there is no limit.



As of 2024, taxpaying consumers can opt to receive the credit at point of sale, rather than only when they file for taxes.

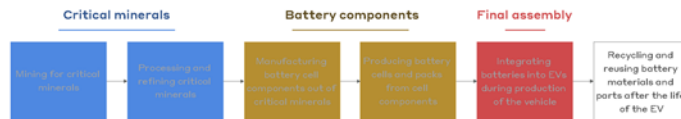


The law includes a new tax credit for used EVs with lower income limits, as well as a new commercial EV tax credit.

Requirements for Vehicle Components and Assembly

Manufacturing EVs and their batteries is a complex process involving several stages of production that can each take place in different countries.

Stages of Electric Vehicle Battery Manufacturing Process



Source: International Energy Agency.

The IRA includes three sets of requirements related to vehicle components and assembly for EV models to qualify for tax credits, with the intention of bolstering domestic production.

Assembly in North America:

As part of the IRA, final assembly of electric vehicle models must occur in North America to be eligible, effective immediately after the enactment of the legislation.

Critical minerals and battery components:

To qualify for the full \$7,500 credit, vehicles must meet two sets of standards related to their vehicle components. If a vehicle only meets one of these two requirements, it qualifies for a \$3,750 tax credit.

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IRA EV Tax Credits: Requirements for Domestic Manufacturing | Bipartisan Policy Center

50% of the value of battery components must be produced or manufactured in North America in fiscal year 2023, with the minimum percentage increasing annually.

40% of the value of critical minerals used for the vehicle must be extracted, processed, and/or recycled domestically or in a country the U.S. has a free trade agreement with, with the minimum percentage increasing annually. EV manufacturing requires a range of minerals, including cobalt, copper, nickel, graphite, and lithium.

However, the Department of Treasury *announced* [<https://home.treasury.gov/system/files/136/3ODWhite-Paper.pdf>] it will need until March 2023 to develop guidance for the critical mineral and battery component requirements, including which countries are considered free trade partners and what activities are considered battery component manufacturing. As a result, these provisions have not been in effect as of February—a delay that invited *criticism* [<https://w>

www.energy.senate.gov/2023/1/icy-mi-manchin-colleagues-debate-american-vehicle-security-act-on-senate-floor/ from Sen. Joe Manchin (D-WV).



Entities of concern: Starting in 2024, vehicles with any battery components manufactured or assembled in an "entity of concern" are not eligible for the tax credit. Beginning in 2025, vehicles with critical minerals extracted, processed, or recycled by entities of concern will not qualify. *Nations of concern* [[https://uscode.house.gov/view.xhtml?req=\(title:42%20section:18741%20edition:prelim\)%20OR%20\(granuleid:USC-prelim-title42-section18741\)&f=treesort&edition=prelim&num=0&jumpTo=true#substructure-location_a_5](https://uscode.house.gov/view.xhtml?req=(title:42%20section:18741%20edition:prelim)%20OR%20(granuleid:USC-prelim-title42-section18741)&f=treesort&edition=prelim&num=0&jumpTo=true#substructure-location_a_5)] include China and Russia.

Notably, requirements for final assembly in North America as well as battery and critical mineral requirements do not apply for the commercial clean vehicles tax credit.

Potential Impact of Domestic Requirements

The congressional intent of the domestic EV content and manufacturing requirements was to support jobs, grow the economy, and protect national security while building energy independence. Beyond just their use in EVs, diversifying critical mineral supply chains, creating increased domestic sources, and insulating them from disruption is necessary in the long run to support decarbonization through clean energy projects.

Currently, the *U.S. accounts for* [<https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf>] only 10% of global EV assembly and 7% of battery production—and a tiny fraction of critical mineral mining and processing. China, on the other hand is responsible for more than 75% of *lithium-ion battery production* [<https://www.>

[csis.org/analysis/ira-and-ev-tax-credits-can-we-kill-multiple-birds-one-stone](https://www.csis.org/analysis/ira-and-ev-tax-credits-can-we-kill-multiple-birds-one-stone)] and supplies over half of the world's processing and refining capacities for lithium, cobalt, and graphite.



Domestic manufacturing standards may not substantially affect the rate of EV sales in the immediate future, because demand has recently outstripped supply due to supply chain and other constraints. In fact, automakers sold every EV they could produce with long waiting lists for some models for much of 2022, though waiting lists have *diminished* [<https://www.nytimes.com/2023/02/10/business/electric-vehicles-price-cost.html>] lately. The challenge Congress tasked automakers with is to adapt their manufacturing operations to meet increasing standards over the next decade while building up sufficient supply to satisfy the growing demand for EVs. Meeting IRA standards necessitates also increasing domestic critical mineral mining—efforts underway and supported by some of the steps Congress has taken discussed below.

Building Supply Chain Capacity

The American auto industry is better prepared to meet the final assembly requirements, with 10 best-selling EV models assembled in the U.S. Ramping up critical mineral and battery production is a greater challenge. Fortunately, a slate of recent policies advance this goal:

The Energy Act of 2020 and the Bipartisan Infrastructure Law (BIL) *together implement* [<https://bipartisanpolicy.org/blog/getting-serious-about-critical-materials-the-iijsa-and-energy-act-of-2020/>] several new programs and initiatives to drive innovation in processing, recycling, and alternatives for critical

minerals. Notably, the BIL includes *\$2.8 billion* [<https://www.energy.gov/articles/biden-harris-administration-awards-28-billion-supercharge-us-manufacturing-batteries#:~:text=The%2020%20companies%20will%20receive,manufacturing%20components%20from%20recycled%20materials.>] awarded to 20 companies to extract and process critical minerals for EVs and manufacture and recycle battery components.

The Inflation Reduction Act made battery manufacturing and critical mineral processing and mining *eligible activities* [<https://bipartisanpolicy.org/blog/inflation-reduction-act-summary-energy-climate-provisions/>] under the 45X production tax credit.

The BIL and IRA both include measures for a *more efficient federal permitting process* [<https://bipartisanpolicy.org/blog/ijja-provisions-to-accelerate-clean-infrastructure-permitting-and-environmental-review/>], including the establishment of a committee to address critical mineral permitting.

The Biden administration invoked the *Defense Production Act* [<https://www.nytimes.com/2022/03/31/business/economy/biden-minerals-defense-production-act.html>] and leveraged the *DOE's Loan Program Office* [<https://bipartisanpolicy.org/blog/clean-energy-supply-chain-troubles-lpo-is-here-to-help/>]—which is also *supported* [<https://www.energy.gov/lpo/inflation-reduction-act-2022>] by the BIL and IRA—to fund the expansion and modernization of critical mineral sites.

The CHIPS and Science Act *supports research* [<https://bipartisanpolicy.org/blog/chips-science-act-summary/>] to advance critical mineral mining strategies and technologies.

Early Signs of Progress

The *Thacker Pass Lithium Mine project* [<https://ndep.nv.gov/land/thacker-pass-project>] in Nevada, which was permitted in 2018, is expected to produce *60,000 tons* [<https://insideclimate.news.org/news/07112021/lithium-mining-thacker-pass-nevada-electric-vehicles-climate/>] of lithium chemicals a year by 2025, about 9% of expected global demand by one estimate. However, local opposition to the project highlights the challenge of bringing new mines online while *limiting pollution, reducing other environmental impacts* [<https://bipartisanpolicy.org/download/?file=/wp-content/uploads/2022/12/Mining-in-the-Future-One-Pager-Final.pdf>], and generating buy-in from local communities. While EVs produce far less in greenhouse gas emissions over their lifecycle than gas vehicles even when accounting for mining, refining, and manufacturing, these processes do require significant *emissions and pose risks* [<https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/sustainable-and-responsible-development-of-minerals>] such as potential biodiversity loss, water pollution, and air pollution. However, other innovative mining projects, such as those at the *Salton Sea* [<https://www.cnbc.com/2022/05/04/the-salton-sea-could-produce-the-worlds-greenest-lithium.html>] in

southern California, are showing early promise for greener mining with robust community support.

Honda and LG Energy made a *\$4.4 billion investment* [<https://www.reuters.com/business/autos-transportation/honda-motor-lg-energy-build-ev-battery-plant-ohio-nikkei-2022-08-29/>] to build a battery plant in the U.S. with mass-production capability projected by 2025. Toyota also announced a *\$3.8 billion investment* [<https://www.reuters.com/technology/toyota-triples-planned-investment-38-billion-us-battery-plant-2022-08-31/>] to build a battery plant in North Carolina. Meanwhile, the Loan Programs Office *recently announced* [<https://www.energy.gov/lpo/articles/lpo-offers-conditional-commitment-redwood-materials-produce-critical-electric-vehicle>] a \$2 billion loan commitment for the construction and expansion of a battery components campus in Nevada, among other loans for battery recycling and lithium and graphite processing.

Conclusion

When it comes to EVs, the IRA aims to have its cake and eat it too—increasing sales through tax credits while limiting those incentives to vehicles developed in North America and trade-partner nations. For this to work, the auto and manufacturing industry will have to rapidly transform their operations to scale up domestic manufacturing quickly.

Industry efforts to meet the IRA's tax credit requirements will be shaped by federal policy. Treasury's upcoming guidance could include added flexibility, for example outlining a broad definition of free trade partners that includes many of our allies. On the flip side, a perceived weakening of domestic content and assembly requirements could anger key congressional champions of these measures. Accelerating domestic manufacturing will also require more *efficient permitting and environmental review processes* [<https://bipartisanpolicy.org/cleaner-smarter-faster-task-force/>].

While it is encouraging to see ambitious investments in EVs and *EV charging* [<https://bipartisanpolicy.org/blog/state-plans-funding-ev-charging/>], the ultimate success of legislation like the IRA will depend on its strategic implementation over the next decade, along with coordination between the public and the private sectors.

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WHITE PAPER

JANUARY 2023

ANALYZING THE IMPACT OF THE INFLATION REDUCTION ACT ON ELECTRIC VEHICLE UPTAKE IN THE UNITED STATES

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This is an updated version to correct an earlier misstatement on our methodology on how the value of the Inflation Reduction Act tax credits are calculated. The previous version can be found at <https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23.pdf>.

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EXECUTIVE SUMMARY

The Inflation Reduction Act (IRA) of 2022 will move electric vehicle (EV) sales into the fast lane for consumers in the United States across all vehicle types. The \$370 billion allocated to climate and clean energy investments dramatically expands tax credits and incentives to deploy more clean vehicles, including commercial vehicles, while supporting a domestic EV supply chain and charging infrastructure buildout.

IRA transportation sector provisions will accelerate the shift to zero-emission vehicles (ZEVs) by combining consumer and manufacturing policies. Consumer tax credits for new and used EVs and tax credits for commercial EVs, along with individual and commercial charging infrastructure tax credits, will increase sales. Domestic supply-chain incentives and investments will boost EV manufacturing and battery production. Critical mineral mining and refining incentives will bolster industrial development.

These investments come at a critical time as the U.S. pivots toward a clean transportation future, helping reduce the 23 percent of total U.S. greenhouse gas (GHG) emissions that come from road transportation. The IRA clean transportation provisions will speed progress towards the Biden administration's EV and climate goals. The U.S. Environmental Protection Agency (EPA) expects to release proposed rulemakings for GHG standards for both light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs) in 2023, and these standards can build upon the progress made by the IRA.

This study assesses the future impact of the IRA on electrification rates for LDV and HDV sales in the United States through 2035. We analyze the value of the personal and commercial EV tax credits, factoring in the various supply chain, income, and price caps on new EVs, and combine this with new estimates of future light-duty and heavy-duty EV cost declines. We find that, on average over the period 2023–2032, the IRA tax credits will reduce light-duty EV purchase costs by \$3,400 to \$9,050. Using methodologies from the Energy Policy Simulator, we project how these changing costs and incentives over time will affect the LDV and HDV markets in the United States.

We consider Low, Moderate, and High scenarios, depending on how certain provisions of the IRA are implemented and how the value of incentives is passed on to consumers. For LDVs, we also consider a range of states that may ultimately adopt California's new Advanced Clean Cars rule (ACC II), which requires increasing EV sales shares for automakers. For HDVs, we consider states that have adopted California's Advanced Clean Trucks rule and its ZEV targets. These results do not consider federal GHG standards for model years 2027 and beyond.

Figure ES-1 shows the range in our projected EV and ZEV sales shares for LDVs and HDVs from 2023 to 2035. This figure presents our Low, Moderate, and High scenarios, compared to a baseline (no IRA incentives) scenario. Here, we use the term EVs for new light-duty battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). For heavy-duty, the term ZEVs includes new BEVs and hydrogen fuel cell electric vehicles (FCEVs). Used EVs are not included in this analysis.

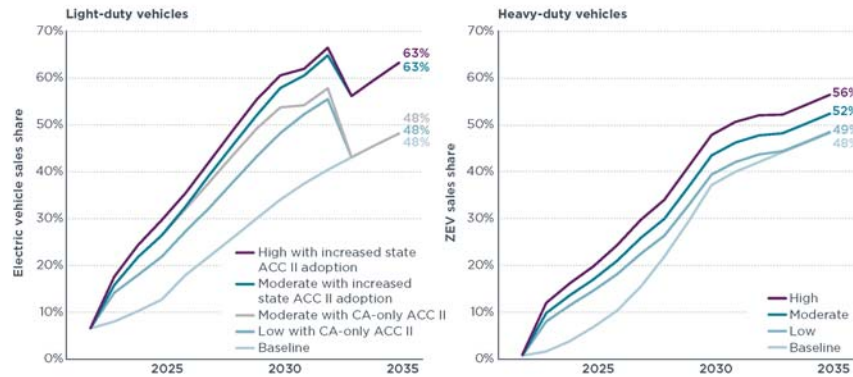


Figure ES-1: Baseline, Low, Moderate, and High projections of EV sales share for light-duty vehicles, considering ACC II adoption in only California versus increased states (left), and ZEV sales share for heavy-duty vehicles with the IRA incentives, 2023-2035 (right)

From these results we draw the following conclusions and policy recommendations:

- » **The IRA will accelerate electrification.** For both the light and heavy-duty sectors, we find rapid EV uptake when considering both expected manufacturing cost reductions and the IRA incentives, as well as state policies. By 2030, we find a range of a 48%-61% EV sales share in the light-duty sector, increasing to 56%-67% by 2032, the final year of the IRA tax credits. For heavy-duty, we estimate a range of 39%-48% ZEV sales share by 2030 and 44%-52% by 2032.
- » **The IRA enables more stringent federal vehicle standards at a lower cost and higher benefit to consumers.** By providing thousands of dollars in financial incentives to LDV and HDV purchasers, the IRA unlocks widespread consumer benefits while furthering the administration's decarbonization goals. With the IRA, EPA can set more stringent federal LDV and HDV GHG standards than would have been possible otherwise, at lower cost and higher benefit to consumers and manufacturers.
- » **The IRA alone is not enough to meet our climate goals.** Previous analyses have found that higher rates of electrification than what we show here will be necessary to meet the U.S. Nationally Determined Contribution (NDC) and to be aligned with the Paris Climate Agreement to limit global warming to well below 2 degrees Celsius.
- » **Federal standards can lock in and build on the pace of electrification from the IRA.** The EV and ZEV sales shares we present are not guaranteed and there remains uncertainty in the electrification transition, especially after the IRA tax credits expire. Federal standards can serve as a backstop to ensure the electrification momentum from the IRA continues, particularly after the incentives expire in 2032. Our results suggest that to be technology forcing and deliver substantial climate benefits above the baseline, federal standards would need to drive electrification rates significantly higher than 50% by 2030 for LDVs and above 40% by 2030 for HDVs.

» **Additional action is needed by government and industry.** This analysis shows that, given costs and consumer preferences, electrification can be rapid. It does not account for other non-financial barriers such as lead time for vehicle manufacturing and charging infrastructure development; these challenges are largest in the heavy-duty sector. The rates of electrification we project here can only be achieved if government and industry invest quickly in ZEV assembly and infrastructure.

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INTRODUCTION

U.S. climate policy took a major step forward with the passage of the Inflation Reduction Act (IRA) of 2022. The \$370 billion allocated to climate and clean energy investments are expected to deliver deep emission reductions across all sectors of the economy. Such investments come at a critical time as the country seeks to pivot towards clean energy and transportation, reverse its laggard position, and emerge as a global leader on electric vehicles (The White House, 2021). In 2021, the Biden administration called for a 50% electric vehicle sales share for passenger vehicles in 2030 in order to strengthen U.S. leadership on clean vehicles, create good-paying jobs, expand clean vehicle manufacturing, and export electric vehicles globally. The administration also has targets for commercial vehicles: in 2022, the United States committed to a minimum zero-emission heavy-duty vehicle (HDV) sales share of 30% by 2030 and 100% by 2040 (Minjares, 2022).

Several key on-road transportation sector provisions are included in the IRA which will greatly accelerate the shift to plug-in electric and hydrogen fuel cell electric vehicles.¹ Consumer tax credits for new and used electric vehicles, tax credits for electric commercial vehicles, and individual and commercial charging infrastructure tax credits will accelerate market growth. At the same time, domestic supply-chain incentives and investments for electric vehicle manufacturing, battery production, and critical mineral mining and refining will bolster industrial development. This package of demand and supply side policies will be critical to putting the United States on a path to transportation decarbonization.

This white paper analyzes the impact of the IRA on light- and heavy-duty electric vehicle market growth in the United States through 2032. Using recent data on electric and conventional vehicle prices, the analysis models consumer vehicle purchase decisions for electric and internal combustion engine vehicle technologies, taking new federal tax credits into account. The methodology section describes the overall analytical approach, the IRA provisions considered, and how they are applied to develop hypothetical scenarios of future EV sales. The results section summarizes the modeling results for electric vehicle sales and sales shares from 2023 through 2035. This is followed by a discussion of policy implications and conclusions.

¹ The IRA's definition of clean vehicles includes plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and fuel cell electric vehicles (FCEVs). In this research note, the term electric vehicles (EVs) refers to both PHEVs and BEVs, unless otherwise specified.

METHODOLOGY

This analysis largely follows the methodology of a 2022 Energy Innovation Policy & Technology LLC² study examining the IRA's impacts on the ground transportation sector (Baldwin & Orvis, 2022). This analysis uses a customized model based on the Energy Policy Simulator (EPS), an open-source policy model (Energy Innovation, 2022). The model forecasts sales of new vehicles from a choice function.² In this study, the model is updated to include the most recent data on U.S. combustion and electric vehicle costs, battery pack costs, vehicle energy consumption, fuel and electricity prices, and charging behavior for electric vehicles. It includes battery electric, plug-in hybrid electric, and gasoline vehicles for light-duty, and battery electric, fuel cell electric, and diesel vehicles for heavy-duty. The light-duty vehicle and battery data on costs, technical specifications, and charging behavior are from a 2022 ICCT assessment of U.S. electric vehicle costs (Slowik, Isenstadt, Pierce, & Searle, 2022). The heavy-duty data are obtained from multiple sources, which are described in detail below. The analysis also incorporates state-level implementation of California's Advanced Clean Cars II and Advanced Clean Trucks Rules to evaluate the combined impact of state regulations and federal incentives on national electric vehicle uptake (California Air Resources Board, 2022a; California Air Resources Board, 2019).

LIGHT-DUTY VEHICLES

The consumer vehicle choice model uses a logit allocation function to estimate the impact of select IRA incentives on new light-duty vehicle sales. The logit function allocates new vehicle purchases to electric and combustion vehicle technologies based on a total cost of ownership (TCO) analysis. The TCO considers purchase, fuel, maintenance, insurance, parking, license, and registration costs, in addition to monetized barriers (e.g., range anxiety) and tax credits and incentives. A 15% discount rate is applied for all future-year ownership expenditures.

The two key inputs to the logit function are the logit exponent and the shareweights. The logit controls the sensitivity of the choice function to the TCO. A higher absolute value for the exponent will push a higher share of sales to the vehicle type with the lowest TCO as compared to a lower exponent. We utilized the same logit exponent values as used in the Global Change Assessment Model (GCAM) v6, which can be found in the model's input data (Joint Global Change Research Institute, n.d.). The shareweights represent non-cost considerations, such as consumer preference and vehicle availability. The shareweights also serve as a calibrating parameter so that the historical sales share in the allocation aligns with historical sales data. A shareweight value of 0 means the allocation will not assign any of the vehicle shares to that technology. The greater a shareweight is relative to the other shareweights, the greater share it will receive in an allocation. For this analysis, we calibrate shareweights in historical years to align the sales share with historical data, and then phase the shareweight to a value of 1 by 2030 using an s-curve. This approach attempts to reflect non-price barriers to EV adoption such as consumer preference and vehicle availability, which are eliminated by 2030. The shareweights for battery-electric light-duty vehicles start at 0.26 in 2021, based on calibration to align with historical sales shares,

² The choice function uses the modified logit choice function as outlined in the GCAM model. The modified logit computes sales shares using technology-specific shareweights and ownership costs and a common exponent. For more information, see: <https://gcrn.github.io/gcam-doc/choice.html>. The original Energy Innovation² analysis also modeled vehicle fleet turnover, vehicle stock, and energy consumption and emissions. See <https://energyinnovation.org/wp-content/uploads/2022/11/Implementing-the-Inflation-Reduction-Act-A-Roadmap-For-Federal-And-State-Transportation-Policy.pdf>.

then increase to 0.73 in 2025 and 0.99 in 2030. This 2030 shareweight reflects our expectation that electric vehicle uptake in 2030 will be driven primarily by costs, as opposed to being constrained by supply chains, and that consumer preference difference will be marginal (Joint Global Change Research Institute, n.d.).

The IRA tax credits and incentives applied in this analysis of light-duty electric vehicles include Personal Tax Credits for Clean Passenger Vehicles (30D) worth up to \$7,500 and Advanced Manufacturing Production Tax Credits (45X) for batteries worth up to \$45 per kilowatt-hour. Per the IRA, several requirements must be met for new passenger vehicles and their buyers to be eligible for the full clean passenger vehicle tax credit. The analysis incorporates estimates of the share of new vehicles that can meet the new domestic assembly and battery sourcing requirements, and applies eligibility restrictions based on the new manufacturer's suggested retail price (MSRP) and adjusted gross income (AGI) caps. More details about these estimates and how they are developed can be found in Baldwin and Orvis (2022). We do not explicitly consider leased vehicles in our analysis and only model the effect of the Personal Tax Credit for light-duty vehicles. Due to uncertainty on how the restriction on battery component and critical mineral sourcing from "entities of concern" will be implemented, we did not account for this requirement in this analysis.

Average U.S. light-duty vehicle prices for 2023 through 2035 are key inputs to the consumer choice model. Purchase price data for new cars, crossovers, SUVs, and pickups, which together represent all light-duty vehicle sales in the United States, are taken from a 2022 ICCT study of conventional and electric vehicle costs (Slowik, Isenstadt, Pierce, & Searle, 2022). Conventional vehicle prices are compared to battery electric vehicles (BEVs) with electric ranges from 150 to 400 miles and plug-in hybrid electric vehicles (PHEVs) with ranges of 20 to 70 miles. Data on the electric range of U.S. electric vehicle sales in 2020 and 2021 are used to calculate the sales-weighted average electric range of new BEVs and PHEVs, and thus the average costs, for the 2022 base year.³ The average electric range of new BEVs and PHEVs is assumed to increase through 2030. For new BEVs, the sales-weighted average electric range increases from 250 miles in 2022 to 300 miles by 2030. For PHEVs, the sales-weighted average electric range increases from 30 miles in 2023 to 50 miles by 2030. The number of annual electric vehicle sales in each light-duty vehicle class is assumed to resemble that of all new light-duty vehicles in the United States in 2020: 27% cars, 35% crossovers, 23% SUVs, and 15% pickups.⁴

Figure 1 illustrates the sales-weighted average conventional and electric vehicle prices applied in the analysis for 2022 through 2035, before any IRA incentives or tax credits are applied. Average BEV prices decline from about \$40,300 in 2022, to about \$30,800 by 2030, and to \$29,200 by 2035. Price parity with gasoline vehicles is achieved around the 2027–2028 timeframe, driven by continued technological advancements and reduced battery costs.⁵ Conventional vehicle prices increase from about \$32,000 in 2022, to about \$33,100 by 2030, and to about \$33,700 by 2035, along with their improved efficiency. PHEVs have the highest prices due to the complexity of having both the combustion and electric powertrain.

³ Based on EV-Volumes, (2022), <https://www.ev-volumes.com/>

⁴ Cars are 27%, crossovers are 35%, SUVs are 23%, and pickups are 15%. Based on data from the National Highway Traffic Safety Administration (2022).

⁵ Based on Slowik, Isenstadt, Pierce, & Searle (2022), the battery pack cost estimate applied in this analysis is \$131 per kilowatt-hour (kWh) in 2022, \$105/kWh in 2025, \$74/kWh in 2030, and \$63/kWh in 2035. These values are for a BEV with a nominal 50 kWh battery pack and were informed by a 2022 review of battery cost projections from technical research studies, automaker announcements, and other expert sources.

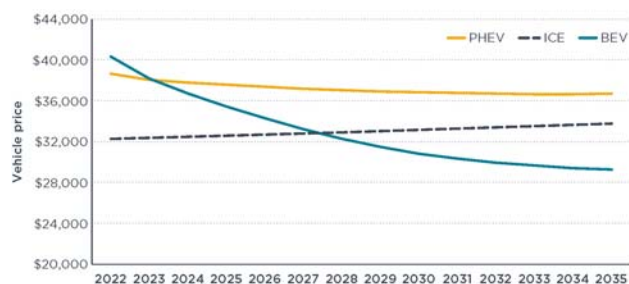


Figure 1. Sales-weighted average conventional and electric vehicle prices applied in this analysis

Several additional factors contribute to the TCO for electric and combustion vehicles that are used in the consumer choice model logit function. Annual fuel costs are calculated using data on conventional and electric vehicle fuel efficiency, annual gasoline and electricity prices, and electric vehicle charging behavior from Slowik, Isenstadt, Pierce, and Searle (2022), and annual vehicle miles traveled is from the Energy Policy Simulator (Energy Innovation, 2022). Per-mile maintenance costs are also from the 2022 ICCT study. Annual vehicle insurance, parking, licensing, and registration costs are from the Energy Policy Simulator and identical for each vehicle technology. This analysis estimates the cost of range anxiety and charging time for BEVs as an additional component of the TCO calculation. The average electric vehicle ownership costs attributed to range anxiety decline from about \$8,000 in 2022 to \$5,500 in 2030 due to greater electric vehicle range and faster charging speeds. Figure 2 illustrates the average TCO for BEVs, PHEVs, and internal combustion engine (ICE) vehicles in this analysis for a 6-year ownership period and 15% discount rate for future-year expenses. As shown, ICE vehicles have the lowest 6-year ownership costs in 2022 and 2025. By 2030, BEVs have lower 6-year ownership costs than their PHEV and ICE vehicle counterparts, which is primarily due to substantial reductions in vehicle price.

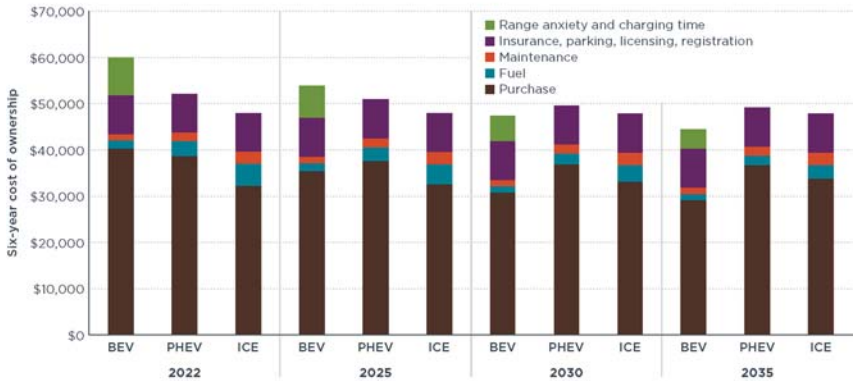


Figure 2. Net present value of six-year ownership costs for new BEVs, PHEVs, and ICE vehicles in 2022, 2025, 2030, and 2035

The IRA tax credits affect the consumer choice model by reducing the TCO for electric vehicles. To analyze the impact of the IRA on U.S. electric vehicle market growth, the analysis includes three hypothetical IRA scenarios—Low, Moderate, and High—that reflect different assumptions surrounding the various IRA provisions. We compare these scenarios against a baseline scenario that excludes the IRA provisions. Table 1 summarizes the three IRA scenarios and how the various electric vehicle incentives, tax credits, and eligibility restrictions are applied for the Passenger Clean Vehicle Tax Credit (30D) and the Advanced Manufacturing Production Tax Credit (45X), using BEVs as an example. The details are discussed below.

Table 1. Summary of Low, Moderate, and High IRA scenarios and how the incentives are applied to battery electric vehicle prices

IRA provision		IRA scenario		
		Low	Moderate	High
Passenger clean vehicle tax credit (30D)	Domestic battery assembly	100% of new BEVs are eligible for the full \$3,750 value		
	Critical minerals sourcing	In 2023, it is assumed that 100% of new BEVs meet the critical minerals sourcing requirements and thus are eligible for the full \$3,750.		
		For future years, the share of new vehicles that meet the requirements are as follows:		
		76% in 2025 56% in 2030 55% in 2032	79% in 2025 72% in 2030 78% in 2032	82% in 2025 89% in 2030 100% in 2032
	MSRP eligibility	87% of new BEVs qualify		
	AGI eligibility	68% of new BEVs qualify in 2023 and 77% qualify in 2030		
	Final vehicle assembly	Sufficient North American assembly capacity to meet demand		
Average 30D incentive value 2023-2032:		\$3,400	\$5,000	\$6,150
Advanced manufacturing production tax credit (45X)	Value of \$45/kWh battery credit passed to consumer, with phase out by 2033	0% for all years	25% in 2023 50% in 2024-2029 37.5% in 2030 25% in 2031 12.5% in 2032 0% in 2033	50% in 2023 100% in 2024-2029 75% in 2030 50% in 2031 25% in 2032 0% in 2033
	Average 45X incentive value 2023-2032:	\$0	\$1,450	\$2,900
Average incentive value of 30D and 45X combined, 2023-2032:		\$3,400	\$6,450	\$9,050

Note: Numbers in table are rounded.

Passenger Clean Vehicle Tax Credit (30D). Up to \$7,500 in consumer incentives are available via the new Passenger Clean Vehicle Tax Credit (30D). Receiving the full amount of \$7,500 requires that new electric vehicles meet new requirements for domestic battery assembly and sourcing of critical minerals, each worth up to \$3,750 (Plug In America, 2023). Based on a previous Energy Innovation[®] analysis, we estimate that 100% of new electric vehicles will comply with the domestic battery assembly requirements and thus be eligible for the full \$3,750 tax credit in each IRA scenario (Baldwin & Orvis, 2022). The share of new electric vehicles that qualify for the critical minerals incentive, and thus the average value of incentives, are also based on Baldwin & Orvis (2022), which used data on electric vehicle battery mineral composition, market shares, and the share of batteries that are sourced domestically or by free trade agreement countries. Beginning in 2023, it is assumed that 100% of new electric vehicles meet the critical mineral requirement for that year. As electric vehicle production increases, a smaller share of new vehicles meet the critical mineral sourcing requirements thereafter. By 2030, it is assumed that 56% of new sales meet the requirements under the IRA Low scenario, 72% meet them under the IRA Moderate scenario, and 100% meet the requirements under the IRA High scenario.

The average value of tax credits is further reduced due to new eligibility restrictions based on the MSRP, adjusted gross income (AGI), and final vehicle assembly. The new tax credits include an MSRP cap of \$55,000 for sedans and \$80,000 for SUVs and pickup trucks. The credits also include an AGI cap of \$150,000 for individuals and \$300,000 for a joint household. It is estimated that 87% of new BEVs will meet

the MSRP requirements for all years in the analysis. It is estimated that 68% of new BEV sales meet the AGI limits in 2023, which increases to 77% in 2030 as the market expands beyond early adopters to the majority market. There is also an entities of concern provision that disqualifies any new electric vehicles from the tax credit if any of the battery components or minerals are manufactured, assembled, extracted, processed, or recycled by a foreign entity of concern beginning in the 2024–2025 timeframe.⁶ Here, we did not account for any reduction in incentive eligibility based on this requirement because it is not yet clear how it will be implemented. Eligibility for the incentive is also contingent on the vehicle being assembled in North America; future manufacturing capacity in North America was estimated by Bui, Slowik, and Lutsey (2021) and found to be sufficient to meet demand, thus not restricting incentive eligibility. More information about the Clean Vehicle Tax Credit, the eligibility requirements, and how these incentives are quantified, are outlined in Baldwin and Orvis (2022).

Advanced Manufacturing Production Tax Credit (45X). For the Advanced Manufacturing Production Tax Credit (45X), up to \$45/kWh of the battery production tax credit can be passed on to consumers in the form of reduced upfront vehicle price. From 2024 through 2029, the assumed percentage of the tax credit value passed to consumers is 0% in the Low scenario, 50% in the Moderate scenario, and 100% in the High scenario. For 2023, these values are reduced by a factor of two. By 2030, the 45X production tax credit begins to phase out, and the percentage passed through is reduced by 25% per year until fully expiring in 2033. More details about the modeling of the battery production tax credit are in Baldwin and Orvis (2022).

For each IRA scenario, the table shows the average value of consumer incentives from the clean vehicle tax credit, battery credit, and both incentives combined over the 2022–2033 timeframe. We find that, on average, consumer incentives for new electric vehicle purchases are worth \$3,400 in the IRA Low scenario, \$6,450 in the IRA Moderate scenario, and \$9,050 in the IRA High scenario.

Based on the data from Table 1, Figure 3 shows the average value the IRA incentives (30D) and tax credits (45X) that are applied to average new battery electric vehicle prices for the Low, Moderate, and High IRA scenarios, which include the Personal Tax Credit for Clean Passenger Vehicles (30D) and the Advanced Manufacturing Production Tax Credit (45X) for batteries. Both incentives expire after 2032. As shown, the sales-weighted average value of BEV incentives in the baseline scenario without the IRA quickly phase down as more manufacturers meet the 200,000-vehicle threshold. In the IRA High scenario, where most new electric vehicles meet all IRA eligibility requirements, the sales-weighted average incentive value is about \$10,500 in 2024 and declines to about \$6,800 in 2032. The decline in the average incentive per vehicle is due to the decreasing share of new vehicles that meet the minerals sourcing requirements, along with the phase out of the battery production tax credit beginning in 2030. In the IRA Low scenario, where fewer new electric vehicles comply with the IRA incentive provisions and there are no battery tax credits passed through to consumers, the average incentive is about \$3,400 per vehicle in 2024, \$2,600 in 2027, and \$4,500 in 2032; the “U” shaped curve is the

⁶ Beginning in 2024, new plug-in vehicles will not qualify for the tax credit if the battery components were manufactured or assembled by a foreign entity of concern. Starting in 2025, vehicles will not qualify for the tax credit if the battery's critical minerals are extracted, processed, or recycled by a foreign entity of concern. Foreign entities of concern are entities that are “owned by, controlled by, or subject to the jurisdiction or direction of a government of a foreign country that is a covered nation (i.e., China, Russia, Iran, or North Korea)” (Bond, 2022).

result of a combination of a declining share of new vehicles that meet the critical minerals sourcing requirements and an increasing share of consumers that meet the AGI caps. Average incentives per vehicle in the IRA Moderate scenario decline from about \$7,300 in 2024 to about \$5,600 in 2032.

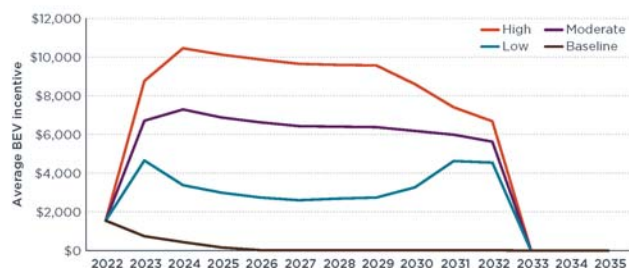


Figure 3. Summary of average IRA incentive values applied to battery electric vehicle prices in the IRA Low, Moderate, and High scenarios

The average BEV incentive values from Figure 3 are applied to the purchase price data for the modeling of consumer choice. Figure 4 shows the average vehicle purchase price for conventional and battery electric vehicles with incentives for the Baseline and Low, Moderate, and High IRA scenarios. As shown, with incentives in the IRA scenarios, upfront price parity is reached in the 2023-2025 timeframe, which is about 3-5 years sooner than without incentives. In the High IRA scenario, the IRA incentives and tax credits reduce electric vehicle prices by up to \$10,500, and new BEVs are about \$7,000 to \$11,000 cheaper than conventional vehicles in the 2025-2030 timeframe.

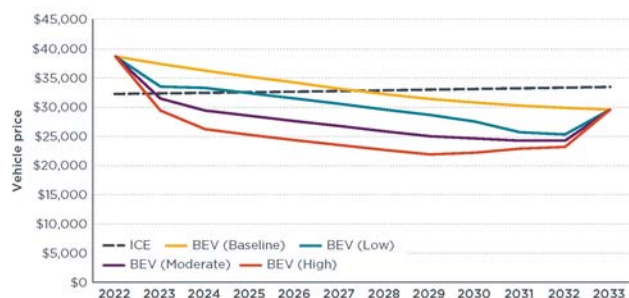


Figure 4. Sales-weighted average new ICE and BEV prices with IRA incentives and tax credits applied

Two additional scenarios are combined with the three IRA scenarios above to incorporate the effects of the state-level Advanced Clean Cars II (ACC II) regulation

on national electric vehicle uptake.⁷ First, a California-only scenario assumes that California is the only state that implements the ACC II regulation, which requires 100% of new light-duty vehicle sales in the state to be battery electric, hydrogen fuel cell electric, or plug-in hybrid electric by 2035. Second, an Increased ACC II state adoption scenario assumes that all of the states that have adopted ACC I will also adopt ACC II, including California, Colorado, Connecticut, Delaware, Maine, Maryland, Massachusetts, Minnesota, Nevada, New Jersey, New Mexico, New York, Oregon, Rhode Island, Vermont, Virginia, and Washington. States that adopt ACC II are assumed to implement the regulation by model year 2026 or 2027. In both scenarios, the annual targets from California's regulation are used to model electric vehicle uptake in the states adopting ACC II, which are incorporated into the national-level projections from the IRA analysis. The modeled electric vehicle shares in states adopting ACC II increase from 35% in 2026, to 68% in 2030, and to 100% in 2035 (California Air Resources Board, 2022a). The results section discusses the impact of these additional scenarios on our findings in more detail.

HEAVY-DUTY VEHICLES

This study assesses heavy-duty vehicles in Classes 4–8. The retail prices for different zero-emission heavy-duty truck and bus classes are estimated using a bottom-up approach following a methodology developed in two previous ICCT studies: Basma, Saboori, and Rodríguez (2021) and Basma, Zhou, and Rodríguez (2022). This approach considers the vehicle's technical specifications and the individual component manufacturing costs, such as the battery, fuel cell, hydrogen tank, electric drive, electric auxiliaries, and others. These costs are summarized in Sharpe and Basma (2022) and are adjusted to consider average inflation in the United States between 2020 and 2022. The aggregated vehicle manufacturing cost is then converted into retail price using indirect cost multipliers that capture expenses related to research and development, overhead, marketing and distribution, warranty expenditures, and profit markups, as defined in U.S. Environmental Protection Agency and U.S. Department of Transportation (2016). The diesel vehicle retail prices are estimated by averaging publicly available price data in Hunter, Penev, Reznicek, Lustbader, Birky, and Zhang (2021), Burnham, et al. (2021), International ZEV Alliance (2020), California Air Resources Board (2022b), Argonne National Laboratory (2022), Burke and Sinha (2020), and Nair, Stone, Rogers, and Pillai (2022). These retail price estimates are detailed further in a separate publication (Xie, Basma, & Rodríguez, in press).

Retail prices of heavy-duty BEVs and hydrogen fuel cell electric vehicles (FCEVs) before and after IRA incentives are compared with diesel heavy-duty vehicles in Figure 5. Even before IRA incentives are applied, BEVs are projected to reach retail price parity prior to 2030 for Class 4–5 and Class 6–7 rigid trucks, refuse trucks, and transit buses. The IRA incentives accelerate the dates of retail price parity for BEVs to prior to 2030 for Class 8 rigid trucks, short-haul tractor trucks, and all bus classes. Long-haul tractor trucks are the only class for which BEVs do not reach retail price parity within the timeframe of this study, even after IRA incentives. However, the incentives roughly halve the price premium of BEVs compared to diesel long-haul tractor trucks in 2030. In contrast to BEVs, FCEVs are projected to reach retail price parity with diesels only for refuse trucks and some bus classes. As in the case of BEVs, the IRA incentives substantially reduce the price premium of FCEVs for all classes.

⁷ See Bui, Hall, and Searle (2022).



Figure 5. Comparison of BEV and FCEV retail prices with diesel heavy-duty vehicles before and after IRA incentives

The technical specifications of the vehicles are defined based on commercial zero-emission heavy-duty trucks and buses currently available in the United States. Battery and hydrogen tank sizes are based on the vehicle's fuel consumption per mile and the average daily mileage. These parameters are provided in the appendix.

The vehicles' miles per gallon (MPG) are estimated by averaging data based on NREL (2021), ANL (2021), and CARB (2020), and the vehicle average daily mileage data is extracted from MOVES3 for each heavy-duty vehicle class. For small buses, we assumed the same efficiency as for rigid trucks (Class 4-5) for each type of technology. For diesel school buses and other diesel buses, we assumed vehicle efficiency follows the Phase 2 standards for coach buses for model year 2027. For school buses, we assumed the same ratio of BEV to diesel and FCEV to diesel efficiency as for rigid trucks (Class 6-7). For other battery electric and fuel cell electric buses, we assumed the same energy efficiency ratios as for long-haul tractor trucks.

Heavy-duty BEV and FCEV costs are further reduced by the amount of the Qualified Commercial Clean Vehicles Tax Credit (45W) for the years in which it applies (2023-2032). Per the IRA provisions, the value of the tax credit is calculated as the lesser of the incremental cost of a BEV or FCEV compared to its diesel equivalent using the estimated costs in Figure 5, 30% of the cost of the vehicle, or \$40,000 (Internal Revenue Service, 2022). We also apply the Advanced Manufacturing Production Tax

Credits (45X) for batteries, based on the battery sizes in Table A1 in the appendix and following the same assumptions as described in the section on light-duty vehicles.

Because vehicle sales shares are projected based on the total cost of ownership, fuel and charging costs are also incorporated in our model. Forecasted diesel prices are taken from the U.S. Energy Information Administration (2022). We estimate the trucks' charging costs by accounting for average electricity rates, charging station costs, and estimated grid upgrade costs. This includes a combination of public and private charging, depending on the vehicle class. Electricity rates vary among and within states depending on utility regulation, type of utility, the presence of regional utilities, and other factors. For this analysis, we collected electricity rate data for seven representative states (California, New York, Texas, Florida, Georgia, Illinois, and Washington), covering different geographic regions and a broad price spectrum while focusing on states with high trucking activity. The electricity rates offered by the biggest utility in each state are used, focusing on primary grid connection applications in which there is a connection to the high-voltage distribution grid. We include demand charges. We then calculate the weighted-average charging cost at the U.S. federal level, providing higher weights for states with higher trucking activity. Data for charging equipment and grid upgrade expenses are adopted from Jesse, Mishra, Miller, Borlaug, Meintz, and Birky (2022). Electricity rate data for the states listed above were collected from PG&E (2022), National Grid US (2022), PSE (2022), ComEd (2022), FPL (2022), Oncore (2022), and Georgia Power (2022). The resulting federal average charging cost in 2022 is 0.1728 \$/kWh, out of which ~ 0.047 \$/kWh corresponds to charging station and grid upgrade costs.

We follow the methodology developed in a previous ICCT study to estimate the cost of hydrogen fuel for heavy-duty FCEVs. We assume electrolysis is performed on-site at hydrogen refueling stations using renewable electricity, producing green hydrogen (Zhou & Searle, 2022). Thus, the at-the-pump hydrogen price consists of two components, the green hydrogen production cost and the hydrogen refueling station cost. This model, while compromising a smaller production capacity, avoids costs and potentially prolonged infrastructure construction, such as pipelines, to deliver hydrogen. We factor in the impacts of the IRA on hydrogen production costs by applying the renewable electricity (section 45 and 45Y) and clean hydrogen (section 45V) tax credits from 2023 to 2032. Detailed methodology and results for our estimated green hydrogen costs are in the appendix.

We assume the Advanced Clean Trucks (ACT) rule is followed in states that had adopted it as of October 2022 (California Air Resources Board, 2019). The ACT rule requires heavy-duty vehicle manufacturers to sell zero-emission vehicles (ZEVs) as increasing shares of their annual sales from 2024 to 2035. By 2035, ZEV sales would need to be 75% of Class 4–8 straight truck sales and 40% of tractor truck sales to meet these requirements. The states that have adopted the ACT rule include California, Massachusetts, New Jersey, New York, Oregon, and Washington (Electric Trucks Now, 2022). Our assumptions on ZEV uptake in ACT states are the same for all scenarios.

The model structure is the same as for light-duty vehicles above, and shareweights from the GCAM input data are also used.

RESULTS

This section summarizes the findings for new U.S. electric vehicle sales and sales shares from 2023 through 2035. The results are presented first for light-duty vehicles followed by heavy-duty vehicles.

LIGHT-DUTY VEHICLES

Figure 6 summarizes the findings of light-duty electric vehicle shares for 2022 through 2035 for the five scenarios: baseline, IRA Low with California-only ACC II, IRA Moderate with California-only ACC II, IRA Moderate with increased state ACC II adoption, and IRA High with increased state ACC II adoption.

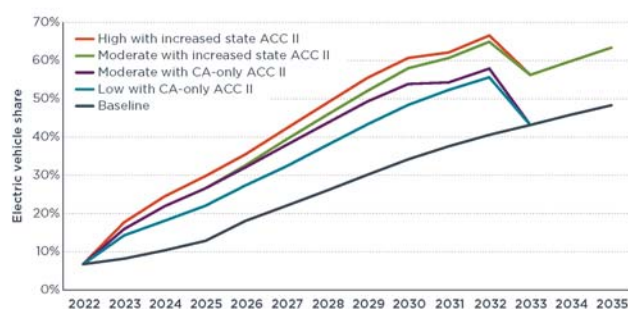


Figure 6. U.S. light-duty electric vehicle sales share for five scenarios, 2022-2035

As shown, electric vehicle sales shares under the baseline scenario increase from about 7% in 2022 to about 13% by 2025, 34% by 2030, and 48% by 2035. With the IRA, electric vehicle prices are reduced and electric vehicle sales shares increase. Under the IRA Low scenario with California-only ACC II adoption, national electric vehicle sales shares reach about 22% by 2025 and about 48% by 2030. Under the IRA High scenario with increased state ACC II adoption, national electric vehicle sales shares increase to about 30% by 2025 and about 61% by 2030. The gap in electric vehicle sales shares between the baseline scenario with no IRA and the IRA scenarios illustrate the effect of the purchase incentives and battery tax credits on consumer purchase decisions. Compared to the baseline scenario, the projected electric vehicle sales shares are nearly doubled in the IRA High with increased state ACC II adoption scenario. Based on our analysis, 2030 electric vehicle sales shares with the IRA range from about 48% (Low) to about 61% (High), indicating the potential for the policy to deliver on President Biden's 2030 50% electric vehicle sales share target.

The decline in electric vehicle sales shares from 2032 to 2033 is due to the expiration of the IRA Personal Tax Credits for Clean Passenger Vehicles (30D) and Advanced Manufacturing Production Tax Credits (45X) for batteries at the end of 2032. By 2033, electric vehicle shares under the IRA Low and IRA Moderate with California-only ACC II scenarios are identical to that of the baseline, because the baseline scenario also assumes that California is the only state with the ACC II regulation. For the IRA High and IRA Moderate scenarios with increased state ACC II adoption, the 2033 electric

vehicle sales shares are about 15% greater than the baseline due to increased sales in additional states with the ACC II regulation. From 2033 to 2035, electric vehicle shares continue to increase as technology costs continue to decline (Figure 1).

Table 2 summarizes the electric vehicle sales shares from 2022 through 2035 for the five scenarios, which are identical to the data from Figure 6. The electric vehicle shares include both BEVs and PHEVs. PHEVs, which on average have higher purchase prices than both battery electric and conventional vehicle technologies, account for 12%-14% of the electric vehicle sales in 2023, and this fraction declines to 5%-8% by 2035, depending on the scenario.

Table 2. Summary of electric vehicle sales shares for five scenarios, 2022-2035

Scenario	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Baseline	6.7%	8.1%	10.3%	12.8%	18.0%	22.0%	26.0%	30.1%	34.1%	37.6%	40.5%	43.2%	45.8%	48.2%
Low with CA-only ACC II	6.7%	14.3%	18.0%	21.9%	27.3%	32.3%	37.9%	43.3%	48.3%	52.3%	55.6%	43.2%	45.8%	48.2%
Moderate with CA-only ACC II	6.7%	15.9%	21.9%	26.5%	32.1%	37.8%	43.6%	49.3%	53.8%	54.3%	57.9%	43.2%	45.8%	48.2%
Moderate with increased state ACC II adoption	6.7%	15.9%	21.9%	26.5%	32.6%	39.3%	45.8%	52.1%	57.9%	60.6%	64.9%	56.2%	59.8%	63.3%
High with increased state ACC II adoption	6.7%	17.7%	24.4%	29.8%	35.5%	42.2%	48.9%	55.5%	60.6%	62.0%	66.5%	56.2%	59.8%	63.3%

Table 3 summarizes the findings for electric vehicle sales shares in non-ACC II states, calculated as the difference between the national-level projections from Table 2 and state-level projections for ACC II states based on the annual regulatory requirements, and taking total light-duty vehicle sales into account. Electric vehicle sales shares in the non-ACC II states lag those of ACC II states. Under the baseline scenario, EV shares in non-ACC II states increase from about 16% in 2026, to about 30% by 2030, and to about 35% by 2032. With the IRA, across all modeled scenarios, incentives reduce electric vehicle prices and sales increase as a result. In the IRA Low scenario, EV sales shares in non-ACC II states increase from about 26% in 2026, to about 46% in 2030, and to about 52% in 2032. Electric vehicle sales shares are highest under the IRA High scenario, increasing from about 36% in 2026, to about 56% in 2030, and to about 57% in 2032. Sales shares in non-ACC II states under the IRA Moderate scenario are approximately halfway between the Low and High scenarios and are identical for the California-only ACC II and increased state ACC II scenarios. The decline in non-ACC II state EV sales shares after 2032 is due to the expiration of the IRA incentives, and EV sales shares in non-ACC II states are consistent across all scenarios over this timeframe.

Table 3. Summary of electric vehicle share in all non-ACC II states combined, 2026-2035

Scenario	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Baseline	15.8%	19.2%	22.7%	26.2%	29.6%	32.4%	34.9%	37.2%	39.3%	41.3%
Low with CA-only ACC II	26.3%	30.9%	36.1%	41.2%	45.7%	49.2%	52.0%	37.2%	39.3%	41.3%
Moderate with CA-only ACC II	31.7%	37.1%	42.6%	48.0%	51.9%	51.4%	54.7%	37.2%	39.3%	41.3%
Moderate with increased state ACC II adoption	31.2%	37.1%	42.6%	48.0%	51.9%	51.4%	54.7%	37.2%	39.3%	41.3%
High with increased state ACC II adoption	35.8%	41.7%	47.6%	53.3%	56.2%	53.7%	57.3%	37.2%	39.3%	41.3%

HEAVY-DUTY VEHICLES

Figure 7 presents our estimated sales shares of heavy-duty ZEVs, which includes both battery electric and hydrogen fuel cell electric vehicles, in the IRA Low, Moderate, and High scenarios, compared to a baseline (no IRA incentives) scenario. The projected ZEV sales shares vary greatly across truck and bus categories, for example from 11% to 17% for long-haul tractor trucks and from 70% to 77% for Class 4-5 rigid trucks in 2035. For all vehicle categories, ZEV sales shares increase continually until 2030, when the battery production tax credit begins to phase out and the small bus ZEV sales share declines slightly. ZEV sales shares for short- and long-haul tractor trucks are projected to decline in 2032-2033 as the Qualified Commercial Clean Vehicles Tax Credit phases out. ZEV sales shares of all vehicle categories are projected to increase steadily after 2033 as ZEVs continue to become more cost competitive.

Aggregate sales-weighted average heavy-duty ZEV sales shares in 2030 are projected to be 39% in the IRA Low scenario, 44% in the IRA Moderate scenario, and 48% in the IRA High scenario. These shares increase in 2035 to 47%, 52%, and 56% for the IRA Low, Moderate, and High scenarios, respectively.

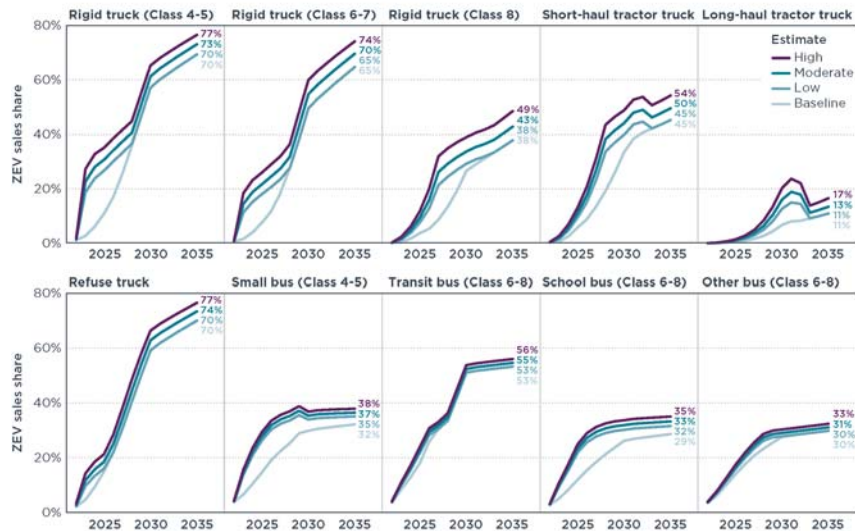


Figure 7. Baseline, IRA Low, IRA Moderate, and IRA High scenarios for U.S. heavy-duty ZEV (BEV + FCEV) sales shares by category, 2022-2035

Our modeling indicates that FCEVs will play only a limited role in the ZEV transition. Table 4 presents the shares of total sales and of ZEV sales that are projected to be FCEVs for each HDV class from 2023 to 2035 in the IRA Moderate scenario. These

trends are similar in the IRA Low and High scenarios. For all truck and bus classes, ZEV sales are projected to be dominated by BEVs. Among truck classes, FCEVs make up less than 1% of total sales in all years. FCEVs are projected to have slightly higher adoption among buses, reaching 6.6% of total sales of transit buses in 2035. The reason FCEVs are projected to play such a limited role in the ZEV transition is due to market fundamentals; in contrast to BEVs, which are projected to have substantially lower operating costs, FCEVs are projected to have higher operating costs than diesels since hydrogen will continue to be more expensive than diesel.

Table 4. FCEV share of total sales and share of ZEV sales by HDV category in the IRA Moderate scenario

FCEV share of total sales in IRA Moderate scenario														
HDV class	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Rigid truck (Class 4-5)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.2%	0.2%	0.0%	0.0%	0.1%
Rigid truck (Class 6-7)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%
Rigid truck (Class 8)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.5%	0.7%	0.8%	0.3%	0.3%	0.4%
Short-haul tractor truck	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.3%	0.4%	0.4%	0.3%	0.3%	0.3%
Long-haul tractor truck	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Refuse truck	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.5%	0.5%	0.5%	0.6%	0.6%	0.7%
Small bus (Class 4-5)	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.4%	0.8%	1.4%	1.5%	1.6%	1.7%	1.9%	2.0%
Transit bus (Class 6-8)	0.0%	0.5%	0.5%	0.6%	1.3%	1.6%	1.7%	3.3%	5.0%	6.0%	6.2%	6.3%	6.5%	6.6%
School bus (Class 6-8)	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.6%	0.7%	0.9%	1.1%	1.4%
Other bus (Class 6-8)	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.3%	0.4%	0.6%	0.7%	0.9%	1.1%	1.4%	1.6%

FCEV share of ZEV sales in IRA Moderate scenario														
HDV class	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Rigid truck (Class 4-5)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%
Rigid truck (Class 6-7)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%
Rigid truck (Class 8)	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.6%	1.6%	1.9%	2.2%	0.8%	0.8%	0.8%
Short-haul tractor truck	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.3%	0.7%	0.8%	0.9%	0.6%	0.6%	0.6%
Long-haul tractor truck	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.2%	0.2%
Refuse truck	0.0%	0.0%	0.1%	0.3%	0.4%	0.5%	0.7%	0.9%	0.7%	0.7%	0.8%	0.8%	0.9%	1.0%
Small bus (Class 4-5)	0.3%	0.5%	0.4%	0.4%	0.7%	0.9%	1.1%	2.1%	4.0%	4.2%	4.5%	4.8%	5.1%	5.5%
Transit bus (Class 6-8)	0.6%	4.9%	3.3%	2.5%	4.6%	4.9%	4.8%	7.6%	11.3%	11.4%	11.5%	11.7%	11.9%	12.1%
School bus (Class 6-8)	0.3%	0.2%	0.2%	0.2%	0.3%	0.4%	0.6%	0.9%	1.4%	1.8%	2.2%	2.8%	3.4%	4.1%
Other bus (Class 6-8)	0.8%	0.7%	0.6%	0.6%	0.7%	0.8%	1.0%	1.4%	2.0%	2.5%	3.1%	3.7%	4.4%	5.1%

DISCUSSION AND POLICY RECOMMENDATIONS

This analysis finds that, with the combined effects of the IRA and technology improvements that will drive down ZEV manufacturing costs, the United States will see rapid electrification over the coming decade. By 2030, we find a range of 48%–61% EV sales share in the light-duty sector, increasing to 56%–67% by 2032, the final year of the IRA tax credits. For heavy-duty, we estimate a range of 39%–48% ZEV sales share by 2030 and 44%–52% by 2032.

We find that the Biden administration's goals of a 50% light-duty EV sales share and a 30% heavy-duty ZEV sales share by 2030 are likely to be exceeded with the influence of the IRA. In the case of heavy-duty vehicles, the administration's target could be exceeded considerably.

However, other analysis has found that the Biden administration's electrification goals would not be sufficient to meet its climate goals. Slowik and Miller (2022) assessed the greenhouse gas (GHG) reductions from light-duty vehicles that are necessary to be compatible with the Paris Climate Agreement to limit global warming to well below 2 degrees Celsius. That analysis found that EV sales shares would need to reach 67% by 2030, coupled with a 3.5% annual increase in the efficiency of combustion engine vehicles, to be compatible with the Paris Agreement. That EV share is higher than the range of results we model here for 2030. Comparing the analysis presented here with the Paris-compatible scenario in Slowik and Miller also shows that, even if all the states that have adopted ACC I also adopt ACC II, the combination of state action and the IRA would still not be sufficient to meet our climate goals.

Other analysis suggests that higher heavy-duty vehicle electrification rates than projected here may also be needed. Buysse, Kelly, and Minjares (2022) find that a heavy-duty ZEV sales share of 46% by 2030 would be needed to be compatible with a scenario of 2 degrees Celsius.

In an earlier analysis using the Energy Policy Simulator model, Orvis, Gopal, Rissman, O'Boyle, Baldwin, and Busch (2022) found that the IRA would significantly reduce GHG emissions, but not enough to put the United States on track to meet its Nationally Determined Contribution commitment to reduce GHG emissions by 50%–52% in 2030 compared to 2005 levels. Thus, additional policy action in the United States is likely necessary to avert the worst effects of climate change.

This analysis is relevant for the U.S. Environmental Protection Agency's next round of rulemaking on light-duty and heavy-duty vehicles. The agency plans to release new proposals for GHG standards by the end of March 2023 (U.S. Environmental Protection Agency, 2022). Because our analysis projects EV and ZEV penetration rates in the absence of federal standards, it can be viewed as a baseline for the purposes of setting those standards. To deliver climate benefits, the new standards will need to advance technology improvements, which could include both electrification as well as efficiency improvements in combustion engine vehicles, faster than is expected under the baseline. Our analysis suggests that setting light-duty standards consistent with an EV penetration rate significantly greater than 50% and heavy-duty standards consistent with a ZEV penetration rate significantly greater than 40% in 2030 may be necessary to deliver additional climate benefits. Another way of viewing our results is that, because of the opportunity for the IRA to deliver such high electrification rates, the federal GHG standards can achieve even greater EV and ZEV penetration and consumer benefits at potentially little additional cost to consumers and automakers.

There is also a role for federal GHG standards to act as a backstop to the IRA and ensure continued growth in EV and ZEV sales shares. The IRA tax credits are set to expire after 2032, and we find that progress in electrification slows after that year. In addition, there is uncertainty in any policy and it is possible that the tax credits could be affected by new legislation or by changes in implementation by future administrations. Setting strong federal GHG standards can help ensure progress in EV and ZEV deployment continues in the face of uncertainty in IRA implementation.

Our modeling approach carries limitations. The GCAM model logit function is based on a single numerical value that orders consumer purchase preferences. This choice indicator approach does not necessarily capture individual preferences, local variations in cost, and other personal factors that would result in economically inferior choices. Furthermore, should battery prices not decline as predicted or consumer acceptance of electric vehicles stalls, our forecasts could be overly optimistic. Conversely, our estimates could be overly conservative if these factors all turned positive.

There are two key non-financial barriers not accounted for in this study: manufacturing lead time and charging infrastructure lead time. These are both greater challenges for the heavy-duty sector than for LDVs. While EVs accounted for 7% of LDV sales in the first half of 2022 in the United States, heavy-duty ZEV sales number only in the hundreds per year at present (Mock & Yang, 2022; Buysse, 2022). Heavy-duty ZEV assembly lines will need to ramp up quickly to deliver the ZEV numbers we project will be demanded on the basis of cost and consumer preferences. Charging infrastructure for heavy-duty vehicles is also expected to take significantly more time to install than for light-duty, since HDV charging depots will increase the demand on the electricity grid at each location to a much greater extent than LDV charging, necessitating time-consuming grid upgrades (Helou et al., 2022). Utilities, industry, and the government will all need to act early to begin making these changes to enable ZEV deployment.

We find that hydrogen is unlikely to play a major role in decarbonizing the U.S. road transportation sector, even when considering the IRA incentives for hydrogen. In this study, we model the cost of green hydrogen, including the incentives from both the clean hydrogen and renewable electricity tax credits in the IRA. We find that the resulting cost of green hydrogen at the pump will still be very high through 2035 (see Table A1 in the appendix). We estimate a sales share of less than 1% for hydrogen FCEVs in each of the truck classes analyzed here. We find up to a 7% FCEV penetration in transit buses, with less than a 2% FCEV sales share for the other bus classes in 2035 (Table 4). Our analysis suggests that battery electric technology will dominate electrification for heavy-duty vehicles. We did not consider light-duty hydrogen vehicles in this analysis.

New guidance from the Treasury Department in December 2022 establishes leased vehicles as eligible for the commercial vehicle tax credit of \$7,500 (Internal Revenue Service, 2022). We did not explicitly consider leased light-duty vehicles in our analysis, but do not expect it would greatly change our results. The share of new EVs that are leased has been declining, representing only about 10% of new electric vehicles in the third quarter of 2022 (Webb, 2022). Moreover, the commercial vehicle tax credit is capped at the incremental cost of a BEV compared to a conventional vehicle. As our cost analysis finds that most light-duty EVs will reach cost parity with gasoline vehicles before 2030, we expect the commercial vehicle tax credit to offer a financial benefit compared with the personal tax credit for only the next few years.

We note several uncertainties and limitations, as well as opportunities for additional research. The projections of EV and ZEV uptake in this study are dependent on the choice of logit exponents and shareweights. In this analysis, these parameters are selected to reflect historical consumer preferences for conventional technology and supply chain constraints. In the future, consumer preferences could change to a greater extent than explored here. Future supply chain development, particularly for materials used in battery production, is uncertain, as is infrastructure availability. Infrastructure needs for the heavy-duty sector, purchase price and total cost of ownership projections for battery electric and fuel cell electric heavy-duty vehicles, and analysis of the heavy-duty vehicle electrification pace necessary to meet our climate goals, will be addressed in forthcoming ICCT publications.

CONCLUSIONS

This study assesses the combined impacts of technology improvement and the IRA tax incentives on EV and ZEV deployment rates from 2023 to 2035. From the results presented here, we draw the following conclusions:

- » The IRA can potentially drive high rates of electrification over the coming decade. By 2030, we find a range of 48%–61% EV sales share in the light-duty sector, increasing to 56%–67% by 2032, the final year of the IRA tax credits. For heavy-duty, we estimate a range of 39%–48% ZEV sales share by 2030 and 44%–52% by 2032.
- » Additional policy is needed in the United States to avert the worst impacts of climate change. The rates of electrification estimated in this analysis are not high enough to be compatible with the Paris Agreement goals or the U.S. Nationally Determined Contribution.
- » Battery electric technology will likely play a much larger role than hydrogen in decarbonizing the road transportation sector. This analysis finds less than 1% penetration of hydrogen FCEVs in all truck classes, including long-haul tractor-trailers. We find 7% FCEV penetration for transit buses and 2% or lower FCEV sales shares for other bus classes.
- » To deliver substantial additional climate benefits, the U.S. Environmental Protection Agency's federal GHG standards for both light- and heavy-duty vehicles may need to be consistent with electrification rates well above 50% for light-duty and above 40% for heavy-duty vehicles in 2030.
- » Strong federal GHG standards for light- and heavy-duty vehicles will also be needed to ensure that the electrification benefits of the IRA continue after the tax credits expire and in case implementation of the tax credits changes.
- » Additional action is needed by governments and industry to resolve non-financial barriers to electrification. This includes planning ahead to build charging infrastructure for heavy-duty vehicles and investing in the manufacturing of new vehicle technologies.

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APPENDIX

HEAVY-DUTY VEHICLE PARAMETERS

Table A1. Battery sizes in kWh, 2023–2035

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Rigid truck (Class 4–5)	135	134	132	131	129	128	126	125	122	121	120	119	118	117
Rigid truck (Class 6–7)	205	203	201	198	196	194	192	190	185	184	182	181	179	178
Rigid truck (Class 8)	400	396	391	387	383	378	374	370	361	358	355	352	349	347
Short-haul tractor truck	455	450	445	440	435	430	426	421	411	407	404	401	398	394
Long-haul tractor truck	1,157	1,138	1,120	1,101	1,083	1,064	1,046	1,027	990	977	965	952	940	927
Refuse truck	405	401	396	392	388	383	379	374	366	363	360	357	354	351
Small bus (Class 4–5)	120	119	117	116	115	114	112	111	108	107	107	106	105	104
Transit bus (Class 6–8)	450	445	440	435	431	426	421	416	406	403	400	396	393	390
School bus (Class 6–8)	180	179	178	177	176	174	173	172	170	169	168	167	166	165
Other bus (Class 6–8)	680	679	678	677	676	674	673	672	670	668	666	664	662	660

Table A2. Summary of HDVs retail prices before incentive, 2023–2035

HDV class		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Rigid truck (Class 4–5)	Diesel	86k	87k	87k	88k	88k	88k	88k	88k	88k	88k	89k	89k	89k
	BEV	117k	111k	105k	99k	94k	89k	84k	79k	78k	77k	77k	76k	75k
	FCV	324k	298k	273k	249k	225k	201k	178k	156k	153k	151k	148k	146k	143k
Rigid truck (Class 6–7)	Diesel	112k	112k	112k	113k	113k	113k	114k	114k	115k	115k	116k	116k	117k
	BEV	151k	142k	135k	127k	119k	112k	105k	98k	97k	96k	95k	94k	94k
	FCV	378k	348k	319k	291k	263k	236k	209k	184k	181k	178k	174k	171k	168k
Rigid truck (Class 8)	Diesel	159k	160k	161k	161k	162k	162k	162k	162k	162k	162k	162k	162k	162k
	BEV	256k	241k	228k	215k	202k	190k	178k	167k	165k	163k	161k	160k	158k
	FCV	439k	407k	375k	345k	315k	286k	258k	230k	227k	223k	220k	217k	214k
Short-haul tractor truck	Diesel	151k	151k	151k	151k	151k	152k	152k	153k	154k	155k	155k	156k	157k
	BEV	263k	248k	233k	219k	205k	192k	179k	166k	164k	163k	161k	159k	157k
	FCV	452k	418k	385k	352k	321k	290k	260k	231k	227k	224k	220k	216k	213k
Long-haul tractor truck	Diesel	169k	170k	171k	172k	172k	173k	174k	175k	175k	176k	177k	178k	178k
	BEV	478k	443k	410k	378k	348k	318k	291k	264k	259k	254k	249k	244k	239k
	FCV	507k	468k	430k	393k	358k	323k	290k	258k	254k	249k	245k	241k	237k
Refuse truck	Diesel	302k	303k	303k	304k	304k	304k	304k	304k	304k	304k	304k	304k	304k
	BEV	337k	322k	307k	293k	279k	266k	253k	241k	239k	237k	236k	234k	232k
	FCV	537k	502k	468k	435k	403k	372k	341k	311k	308k	304k	300k	297k	293k
Small bus (Class 4–5)	Diesel	77k	78k	78k	79k	79k	79k	79k	79k	79k	79k	79k	79k	79k
	BEV	117k	113k	108k	104k	99k	95k	91k	87k	87k	86k	86k	85k	85k
	FCV	190k	179k	169k	159k	149k	139k	130k	120k	111k	110k	109k	108k	107k
Transit bus (Class 6–8)	Diesel	331k	342k	354k	365k	376k	376k	376k	376k	376k	376k	376k	376k	376k
	BEV	434k	418k	402k	387k	373k	358k	344k	331k	329k	327k	326k	324k	322k
	FCV	566k	540k	515k	490k	466k	443k	420k	398k	376k	373k	370k	367k	365k
School bus (Class 6–8)	Diesel	128k	128k	128k	128k	128k	128k	128k	128k	128k	128k	128k	128k	128k
	BEV	183k	176k	169k	162k	156k	150k	143k	138k	137k	136k	135k	134k	134k
	FCV	308k	290k	273k	256k	240k	224k	208k	193k	178k	176k	174k	173k	171k
Other bus (Class 6–8)	Diesel	630k	634k	634k	634k	638k	638k	638k	638k	637k	637k	637k	637k	637k
	BEV	800k	776k	752k	729k	707k	684k	662k	640k	638k	635k	633k	630k	628k
	FCV	954k	917k	880k	845k	810k	777k	743k	711k	680k	676k	671k	667k	663k

Notes: Prices are in U.S. dollars. The blue shaded cells indicate the years in which purchase price parity is reached between each ZEV technology and diesel vehicles, and later.

Table A3. Sales shares of heavy-duty vehicles by category in the IRA Moderate scenario, 2023-2035

HDV class		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Rigid truck (Class 4-5)	BEV	23%	28%	31%	34%	38%	41%	51%	61%	64%	66%	69%	71%	73%
	Diesel	77%	72%	69%	66%	62%	59%	49%	39%	36%	33%	31%	29%	27%
	FCV	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Rigid truck (Class 6-7)	BEV	14%	19%	22%	25%	28%	32%	43%	55%	58%	61%	64%	67%	70%
	Diesel	86%	81%	78%	75%	72%	68%	57%	45%	42%	39%	36%	33%	30%
	FCV	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Rigid truck (Class 8)	BEV	2%	5%	9%	16%	26%	29%	32%	33%	35%	36%	38%	40%	43%
	Diesel	98%	95%	91%	84%	74%	71%	68%	66%	65%	63%	62%	59%	57%
	FCV	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	0%	0%	0%
Short-haul tractor truck	BEV	2%	6%	11%	18%	27%	38%	41%	44%	48%	49%	46%	48%	49%
	Diesel	98%	94%	89%	82%	73%	62%	58%	56%	52%	51%	54%	52%	50%
	FCV	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Long-haul tractor truck	BEV	0%	1%	1%	2%	4%	6%	10%	16%	19%	18%	11%	12%	13%
	Diesel	100%	99%	99%	98%	96%	94%	90%	84%	81%	82%	89%	88%	87%
	FCV	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Refuse truck	BEV	12%	16%	19%	25%	34%	44%	54%	63%	65%	67%	69%	71%	73%
	Diesel	88%	84%	81%	75%	65%	55%	46%	37%	34%	32%	30%	28%	26%
	FCV	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	1%	1%	1%
Small bus (Class 4-5)	BEV	15%	22%	28%	32%	34%	35%	37%	34%	34%	35%	35%	35%	35%
	Diesel	85%	78%	72%	68%	66%	65%	63%	65%	64%	64%	64%	64%	63%
	FCV	0%	0%	0%	0%	0%	0%	1%	1%	2%	2%	2%	2%	2%
Transit bus (Class 6-8)	BEV	10%	16%	22%	28%	30%	33%	40%	47%	47%	47%	48%	48%	48%
	Diesel	89%	84%	77%	70%	68%	65%	56%	47%	47%	46%	46%	46%	45%
	FCV	1%	1%	1%	1%	2%	2%	3%	6%	6%	6%	6%	6%	7%
School bus (Class 6-8)	BEV	10%	17%	23%	27%	29%	31%	31%	32%	32%	32%	32%	32%	32%
	Diesel	90%	83%	76%	73%	70%	69%	68%	68%	67%	67%	67%	67%	67%
	FCV	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%
Other bus (Class 6-8)	BEV	8%	12%	17%	21%	24%	27%	28%	29%	29%	29%	29%	29%	30%
	Diesel	92%	88%	83%	79%	75%	72%	71%	71%	70%	70%	70%	69%	69%
	FCV	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	2%

GREEN HYDROGEN COSTS

We estimate the production cost of green hydrogen using a discounted cashflow (DCF) model, which calculates the current value of investing in a product by accounting for the producer's future annual cash flows. Detailed model assumptions, including the capital and operational costs and financial assumptions, can be found in Zhou & Searle (2022). For the IRA scenarios in this analysis, we use the same DCF model but change certain inputs following the provisions under this law. The tax credits are only applied in years 2023 to 2032, indicating that only producers that started operating early in 2023 would receive the full 10-year credits. The credits are valued at \$0.026 per kWh and up to \$3 per kg hydrogen, respectively, in 2023, subject to inflation adjustment in future years. Therefore, we assume a 2% annual inflation rate in this study. Per the IRA,

the actual amount of hydrogen tax credit is dependent on its life-cycle greenhouse gas emissions—the higher the emissions, the lower the tax credit. In general, green hydrogen has low enough emissions to qualify for the highest \$3 per kg hydrogen credit,⁸ and the two sets of clean energy tax credits can be combined. In addition, section 6417 of the IRA includes a “direct pay” provision for clean hydrogen producers, where the tax credits are refundable for the first five years of operation. Further, under section 6418, both renewable electricity and clean hydrogen producers are eligible for tax “transferability” by selling their unused tax credits to a buyer who has the tax burden. However, the credits might be transferred, i.e., traded, at a discounted or lower value and could incur due diligence costs (Burton & Vozarova, 2022). Thus, without further details from the IRA, we apply a 15% discount rate to the \$0.026 per kWh or \$3 per kg hydrogen credit values when the unused renewable electricity or clean hydrogen credits are being transferred. Table A4 shows the estimated levelized green hydrogen production cost with and without the IRA tax credits.

Table A4. Levelized production cost of a new green hydrogen production plant entering the market in a given year, with and without the IRA clean energy tax credits.

Year	With no tax credit	With IRA tax credits
2020	5.59	NA
2021	5.48	NA
2022	5.41	NA
2023	5.35	3.29
2024	5.29	3.40
2025	5.21	3.52
2026	5.16	3.69
2027	5.09	3.93
2028	5.02	4.19
2029	4.95	4.43
2030	4.85	4.58
2031	4.80	4.65
2032	4.75	4.68
2033	4.70	NA
2034	4.59	NA
2035	4.54	NA

The hydrogen refueling station (HRS) cost is based on the study by Reddi et al. (2017). Using the results from that study, we assume the levelized HRS cost to be \$6 per kg hydrogen in 2020, decreasing linearly to \$2.3 per kg in 2050. These values are consistent with the assumptions in Zhou & Searle (2022), which were based on a European study (European Commission, 2021). The decreasing cost is a result of economies of scale and greater utilization of the HRS. Section 13404 of the IRA provides tax credits to eligible HRSs of up to \$100,000. We therefore assume a minor 4% lower HRS cost for the IRA scenario.

The estimated hydrogen price in a given year is the cost of a new project entering production in that year and does not necessarily represent the price to the consumer.

⁸ See Zhou, Swidler, Searle, and Baldino (2021).

The consumer price will be set based on competition between all hydrogen suppliers, including those that began production in earlier years. In order to estimate a price more representative of the market for each year, we average the costs of producers beginning production in that year and of all producers that began production in earlier years. We thus implicitly assume a linear increase in the number of new hydrogen producers over time. For example, the at-the-pump hydrogen price in 2030 is the average of the 2020–2022 costs when there were no policy incentives and the 2023–2030 costs with the IRA tax credits. Figure A1 shows the at-the-pump green hydrogen price when a new project enters the market each year between 2020 and 2035 and the calculated market price considering all operating projects in that year.

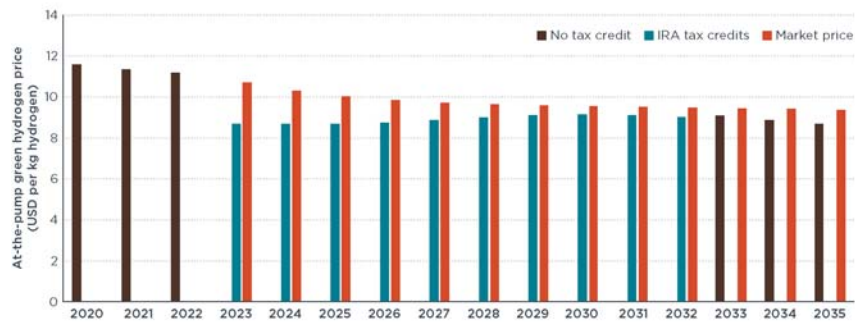


Figure A1. At-the-pump green hydrogen price

DETAILED RESULTS TABLES

Table A5. Projected BEV, PHEV, and total EV sales shares for light-duty vehicles nationwide, 2022-2035

Scenario		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Baseline	BEV	5.3%	7.1%	9.2%	11.5%	16.0%	19.7%	23.5%	27.5%	31.5%	34.9%	37.8%	40.6%	43.2%	45.7%
	PHEV	1.4%	1.1%	1.2%	1.3%	2.1%	2.3%	2.5%	2.6%	2.7%	2.7%	2.6%	2.6%	2.6%	2.5%
	Total EV	6.7%	8.1%	10.3%	12.8%	18.0%	22.0%	26.0%	30.1%	34.1%	37.6%	40.5%	43.2%	45.8%	48.2%
IRA Low with CA-only ACC II	BEV	5.3%	12.3%	15.9%	19.6%	24.4%	29.2%	34.6%	40.0%	45.1%	49.2%	52.5%	40.6%	43.2%	45.7%
	PHEV	1.4%	2.0%	2.2%	2.3%	2.9%	3.1%	3.3%	3.3%	3.2%	3.2%	3.1%	2.6%	2.6%	2.5%
	Total EV	6.7%	14.3%	18.0%	21.9%	27.3%	32.3%	37.9%	43.3%	48.3%	52.3%	55.6%	43.2%	45.8%	48.2%
IRA Moderate with CA-only ACC II	BEV	5.3%	13.8%	19.7%	24.2%	29.2%	34.8%	40.6%	46.4%	50.9%	51.0%	54.8%	40.6%	43.2%	45.7%
	PHEV	1.4%	2.1%	2.2%	2.3%	2.9%	3.0%	3.0%	2.9%	2.9%	3.2%	3.1%	2.6%	2.6%	2.5%
	Total EV	6.7%	15.9%	21.9%	26.5%	32.1%	37.8%	43.6%	49.3%	53.8%	54.3%	57.9%	43.2%	45.8%	48.2%
IRA Moderate with increased state ACC II adoption	BEV	5.3%	13.8%	19.7%	24.2%	29.0%	34.7%	41.0%	47.5%	53.1%	55.1%	59.6%	51.0%	54.6%	58.2%
	PHEV	1.4%	2.1%	2.2%	2.3%	3.6%	4.7%	4.8%	4.6%	4.8%	5.5%	5.3%	5.2%	5.2%	5.1%
	Total EV	6.7%	15.9%	21.9%	26.5%	32.6%	39.3%	45.8%	52.1%	57.9%	60.6%	64.9%	56.2%	59.8%	63.3%
IRA High with increased state ACC II adoption	BEV	5.3%	15.5%	22.5%	27.7%	32.1%	38.2%	44.9%	51.7%	56.5%	56.5%	61.2%	51.0%	54.6%	58.2%
	PHEV	1.5%	2.1%	2.0%	2.0%	3.4%	4.0%	4.0%	3.8%	4.1%	5.5%	5.3%	5.2%	5.2%	5.1%
	Total EV	6.7%	17.7%	24.4%	29.8%	35.5%	42.2%	48.9%	55.5%	60.6%	62.0%	66.5%	56.2%	59.8%	63.3%

SENSITIVITY ANALYSIS RESULTS

Light-duty vehicles

A key component of the logit allocation that determines sales shares is the logit exponent used, which determines the sensitivity of the allocation to the cost parameter. We utilize values from GCAM for this modeling (Joint Global Change Research Institute, n.d.), but note that these values do not appear to be empirically grounded nor updated recently. Given the importance of this component for determining sales shares, the electric vehicle share findings were tested for their sensitivity to variations to the logit exponent. Compared to our analysis above that uses a GCAM value of -8, alternative GCAM values of -6 and -10 (i.e., adding 2 or -2) were applied, reflecting relatively greater and lesser consumer sensitivity to TCO when making purchase decisions. Figure A2 illustrates how the findings of electric vehicle shares vary with adjustments to the logit exponent, indicated by the red hashed area surrounding the black hashed line. As shown, adjusting the logit exponent to -6 and -10 has the greatest effect on projections for electric vehicle shares around the 2030-2031 timeframe, at about +/- 5%; this is because of the incentive. The sensitivity analysis shown in Figure A2 is for the Moderate IRA + increased ACC II adoption scenario, but the effects of adjusting the logit exponent are similar for all scenarios.

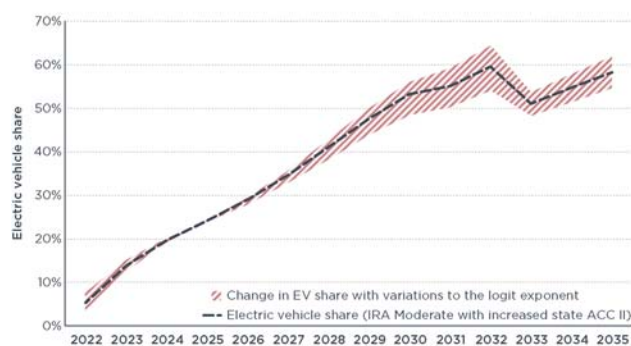


Figure A2. Sensitivity of electric vehicle share findings to variations to the logit exponent, reflecting greater and lesser consumer sensitivity to TCO in purchase decisions. Findings are shown for the IRA Moderate with increased state ACC II adoption scenario.

Heavy-duty vehicles

As with the light-duty vehicle analysis, we test the heavy-duty electric vehicle share findings for their sensitivity to variations to the logit exponent. Compared to the central case of a GCAM value of -8 for non-buses and -3 for buses (i.e., adding 2 or -2) were applied, reflecting relatively greater and lesser consumer sensitivity to TCO, as for light-duty vehicles above. The red hashed areas surrounding the black line in Figure 9 illustrate how the BEV shares for each category of trucks and buses varies with adjustments to the logit exponent. The BEV sales shares for small buses, transit buses, and school buses are more sensitive to the assumption on the logit exponent, while those for short and long haul tractor trucks, Class 8 rigid trucks, and Class 6-8 other buses, are less sensitive to the logit exponent. The sensitivity analysis shown in Figure 9 is for the IRA Moderate scenario, but the effects of adjusting the logit exponent are similar for all scenarios.

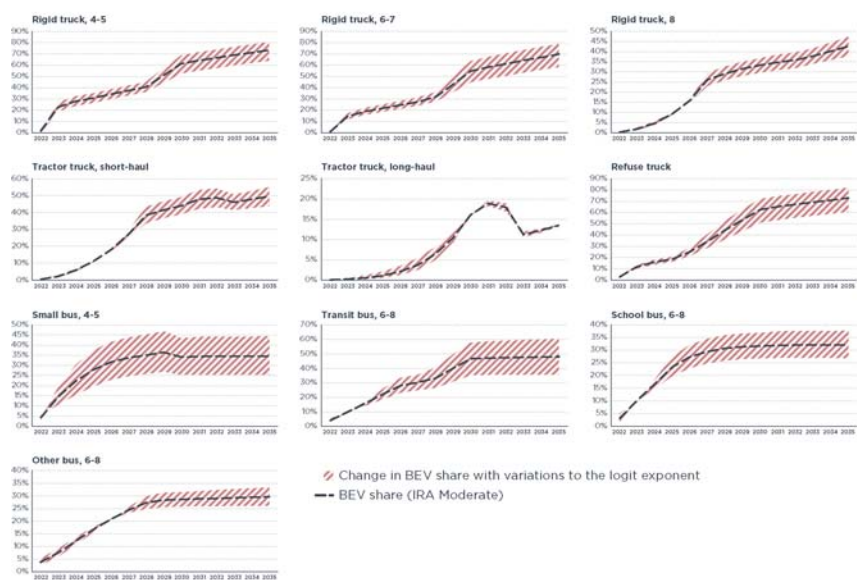


Figure A3. Sensitivity of BEV share findings to variations to the logit exponent for U.S. heavy-duty BEV sales shares by category in the IRA Moderate scenario, 2022-2035.



Sen. Edward Markey (D-MA), Chairman
 Sen. Pete Ricketts (R-NE), Ranking Member
 Senate Committee on Environment & Public Works
 Subcommittee on Clean Air, Climate, and Nuclear Safety
 410 Dirksen Senate Office Building
 Washington, DC 20510

April 18, 2023

Dear Chairman Markey and Ranking Member Ricketts,

Clean Fuels Alliance America is the U.S. trade association representing the biodiesel, renewable diesel, and sustainable aviation fuel supply chain, including producers, feedstock suppliers and fuel distributors. Our industry today – based on 2021 market data – is at the center of \$23.2 billion in economic activity that supports 75,200 domestic jobs earning \$3.6 billion in annual wages. Our members are building domestic production capacity and markets for biodiesel, renewable diesel, sustainable aviation fuel (SAF), Bioheat® fuel, maritime and railroad fuels.

We appreciate your hearing today, Cleaner Vehicles: Good for Consumers and Public Health. Biodiesel and renewable diesel are clean, low-carbon drop-in fuels that can be used today in existing engines, without modifications, to generate immediate reductions in carbon and criteria pollutant emissions. We believe that our industry's growth is consistent with the goals to address environmental health and provide consumer benefits at the pump.

Biodiesel and renewable diesel reduce lifecycle greenhouse gas emissions by more than 70% on average compared to petroleum, according to Argonne National Lab's GREET model. Additionally, biodiesel and renewable diesel reduce particulate matter and hydrocarbon emissions that contribute to cancer, lung, and heart disease rates. Since biodiesel can reduce particulate matter emissions by 45%, communities that increase its use can achieve reductions in lifetime cancer burdens as well as annual asthma attacks and premature deaths.

A study from Trinity Consultants demonstrates substantial potential economic and environmental health benefits for communities in Massachusetts, Nebraska and other states from replacing diesel fuel with biodiesel. The study shows, for instance, that Boston could potentially save close to \$161 million by reducing the cancer risk associated with particulate matter emissions through use of biodiesel. ¹

¹ Trinity Consultants. "[Assessment of Health Benefits from Using Biodiesel as a Transportation Fuel and Residential Heating Oil](#)." Sacramento: March 2022.

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Many fleets across the country use biodiesel and renewable diesel to meet environmental goals today. Because these are drop in fuels, cities and municipalities – such as the District of Columbia – can reduce carbon and particulate matter emissions from existing fleets with minimal costs in infrastructure. Achieving net zero emissions by 2050 and avoiding potential catastrophic climate changes requires measurable carbon reductions today. Research from the State University of New York demonstrates that use of available technologies – like biodiesel and renewable diesel – is the lowest cost method to generate necessary carbon savings considering the timeline and cost of developing new technologies and accompanying infrastructure.²

In 2022, more than 3.7 billion gallons of biodiesel and renewable diesel were available in the U.S. market. Domestic production – not considering imports – topped 3.1 billion gallons. Our fuels currently meet 6 percent of the nation's need for on-road diesel fuel. And industries such as rail, shipping and aviation are also creating demand for cleaner fuels.

A recent study by World Agricultural Economic and Environmental Services shows that diesel fuel prices would be 4% higher without available supplies of biodiesel and renewable diesel. The 4% price benefit at the pump flows through the entire economy lowering the price of transportation for essential items, like food and commodities, as well as other retail goods.³

The U.S. Energy Information Administration (EIA) projects that 5.9 billion gallons of renewable diesel capacity expansions would be completed before 2025.⁴ Independent analysis from the University of Illinois and USDA's Economic Research Service comes to the same conclusion.⁵ Congress and USDA have made significant commitments to support growth of biodiesel and renewable diesel as well as rapid development of sustainable aviation fuel.

² Frank, Jenny & Brown, Tristan & Ha, Hak Soo & Slade, Dave & Haverly, Martin & Malmshiemer, Robert. (2022). Quantifying and comparing the cumulative greenhouse gas emissions and financial viability of heavy-duty transportation pathways for the Northeastern, United States. *Fuel*. 323. 124243. 10.1016/j.fuel.2022.124243.

³ Kruse, J. "[The Offsetting Impact of Expanded Biomass Based Diesel Production on Diesel Prices](#)," WAEES, April 2022.

⁴ Troderman, J. and Shi, E. Domestic renewable diesel capacity could more than double through 2025. *Today in Energy*, Feb. 2, 2023.

⁵ Gerveri, M., T. Hubbs and S. Irwin. "[Overview of the Production Capacity of U.S. Renewable Diesel Plants for 2023 and Beyond](#)," *farmdoc daily* (13):57, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 29, 2023.



We thank Congress for supporting the emergence of our industry and urge you to consider the ongoing benefits of low-carbon fuels for existing fleets today.

Thank you for your consideration,

Kurt A. Kovarik

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Senator MARKEY. Senators will be allowed to submit written questions for the record through the close of business on May 2nd. We will compile these questions, send them to all of our witnesses. We will then ask you to reply by May 16th.

With that, this very important and reformative hearing is adjourned. Thank you.

[Whereupon, at 4:42 p.m., the hearing was adjourned.]

