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Vehicle Electrification: Federal and State Issues Affecting Deployment

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SUMMARY

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Vehicle Electrification: Federal and State Issues Affecting Deployment

Most of the 270 million cars, trucks, and buses on U.S. highways are powered by internal combustion engines using gasoline or diesel fuel. However, improvements in technology have led to the emergence of vehicle electrification as a potentially viable alternative to internal combustion engines. Several bills pending in the 116th Congress address issues and incentives related to electric vehicles and charging infrastructure.

Experience with fully electric vehicles is relatively recent: While a few experimental vehicles were marketed in the United States in the 1990s, the first contemporary all-electric passenger vehicles were introduced in 2010. Since then, newer models have increased the range an electric vehicle can travel on a single charge, and charging stations have become more readily available. These developments have been spurred by a range of government incentives, both in the United States and abroad. Transit buses are the fastest-growing segment of vehicle electrification in China, while in the United States and the European Union, the pace of bus electrification is slower.

In the United States, federal incentives for electric passenger vehicle purchases have remained largely unchanged for more than a decade and are based primarily on tax credits for electric vehicle purchases and recharging infrastructure investments, and spending on battery chemistry research to develop less-expensive technologies:

- The **plug-in electric tax credit** permits a taxpayer to take a credit of up to $7,500 for each vehicle that can be recharged from the electricity grid; it phases out after a manufacturer has sold 200,000 eligible vehicles, a threshold that has been met by Tesla and General Motors.
- A **tax credit for installation of alternative fuel vehicle refueling property** expired in 2017; it had allowed a tax credit of $1,000 for equipment installed at a residence and up to $30,000 for business installations.
- **Investment in transportation electrification research and development (R&D)**, which has led to the gradual reduction in the cost of producing lithium-ion batteries, is administered by the U.S. Department of Energy (DOE) in cooperation with private industry. Although the Trump Administration has recommended large reductions in these programs, Congress has maintained annual funding for sustainable transportation of nearly $700 million in the past two fiscal years.

Other programs that directly influence the level of vehicle electrification include the DOE Clean Cities Program, which supports local efforts to reduce fossil fuel-powered transportation, and the Department of Transportation's Alternative Fuel Corridors, which are designated Interstate Highway corridors with a sufficient number of alternative fueling stations, including electric vehicle chargers, to allow alternative fuel vehicles to travel long distances. The federal government also funds municipal transit bus electrification through Federal Transit Administration grants, which may be used for the purchase of all-electric buses. The pace of electrification also may be affected by proposals for less stringent federal standards for Corporate Average Fuel Economy (CAFE) and greenhouse gas emissions from vehicles.

Beyond these federal programs, states and electric utilities provide a range of incentives for electrification. The National Conference of State Legislatures reports that 45 states and the District of Columbia offer incentives such as income tax credits for electric vehicle and charger purchases, reduced registration fees, and permitting solo drivers of electric vehicles to use carpool lanes. The California Zero Emission Vehicle program is spurring sales of electric vehicles in 10 states. Utilities can provide incentives to charge during off-peak hours, install public electric charging infrastructure, and utilize vehicle-to-grid (V2G) storage. V2G storage would allow idle vehicle batteries to supply electricity to the grid rather than drawing power from it during peak demand periods.

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Introduction

Motor vehicle electrification has emerged in the past decade as a potentially viable alternative to internal combustion engines. Although only a small proportion of the current motor vehicle fleet is electrified, interest in passenger vehicle electrification has accelerated in several major industrial countries, including the United States, parts of Europe, and China. Despite advances in technology, electric vehicles (EVs) continue to be significantly more expensive than similarly sized vehicles with internal combustion engines. For this reason, governments in many countries have adopted policies to promote development and sales of electric vehicles. This report discusses federal and state government policies in the United States to support electrification of light vehicles and transit buses, as well as proposals to reduce or eliminate such support.

Background on Motor Vehicle Electrification

More than 92 million light vehicles—passenger cars, pickup trucks, and SUVs—were sold worldwide in 2018. The three largest markets were China (27 million vehicles sold), Europe (20 million), and the United States (17 million).[1] Most of these vehicles are powered by internal combustion engines.

The global market for electrified vehicles is small but growing: In 2018, more than 2 million plug-in hybrid and battery electric vehicles were sold worldwide, a 64% increase over 2017.[2] These account for about 2% of all passenger vehicle sales, both worldwide and in the United States. Demand for electric vehicles is expected to continue to grow, as some countries have called for a complete shift away from sales of new fossil-fuel vehicles by 2030.[3]

The market for urban transit buses is smaller than the passenger car and SUV markets, but electric vehicles make up a larger part of its footprint. China leads in this category, with 106,000 electric buses put in service in 2017, bringing its total electric bus fleet to 384,000. It has been forecast to remain the largest electric bus market going forward. In the European Union (EU) and the United States, the pace of electrification is slower: More than 200 electric buses were sold in the EU in 2017, bringing the total in service to 1,700; in the United States, approximately 100 electric buses were sold, bringing the total to 300.[4]

Two basic types of electric vehicles are now in use:

- Hybrid electric vehicles (HEVs) have both internal combustion engines and electric motors that store energy in batteries. They do not plug into external

[1] Ward's Database, "China, Europe and U.S. Vehicle Sales 2018." If Canada and Mexico are included, then the North American market would tie with Europe as the second largest.

[2] InsideEVs, "Worldwide Sales of Electric Vehicles," viewed March 5, 2018, at https://insideevs.com/monthly-plug-in-ev-sales-scorecard-historical-charts/.

[3] At least eight countries have set goals of phasing out sales of new internal combustion vehicles by 2030, although apparently none of them has taken binding legislative action. As of September 2018, the following countries have called for no sales of new internal combustion engine vehicles by 2030: Austria, Costa Rica, Germany, India, Ireland, Israel, the Netherlands, and Norway. In addition, France and the United Kingdom have set similar goals for 2040. Isabella Burch and Jock Gilchrist, *Survey of Global Activity to Phase Out Internal Combustion Engine Vehicles*, Center for Climate Protection, September 2018, at https://climateprotection.org/our-work/reports.

[4] Aleksandra O'Donovan, *The Global Electric Bus Market Gets Into Gear (Part 2)*, Bloomberg New Energy Finance, February 1, 2018, pp. 12-14.

sources of electricity, but use regenerative braking and the internal combustion engine to recharge.

- Plug-in electric vehicles, of which there are two types: plug-in hybrid electric vehicles (PHEVs) use an electric motor and an internal combustion engine for power, and they use electricity from an external source to recharge the batteries. Battery electric vehicles (BEVs) use only batteries to power the motor and use electricity from an external source for recharging.[5] In this report, electric vehicles refer to these two types of plug-in vehicles, unless otherwise noted.

Electrification of vehicles has been limited by three factors: (1) the high cost of producing the lithium ion batteries (currently the preferred battery chemistry) that propel them; (2) their limited range; and (3) vehicle charging time and location. Not all motorists have easy access to charging stations at home or at work, and it can take several hours to fully charge the battery that powers the vehicle, depending on the type of charger used.

U.S. Trends

In 2018, more than 361,000 plug-in electric passenger vehicles (including PHEVs and BEVs) were sold in the United States, as well as more than 341,000 hybrid electric vehicles. This was the first year in which total sales of plug-in vehicles exceeded sales of hybrids **(Figure 1)**. Nearly all automakers offer electric vehicles for sale: 42 different models were sold in 2018, with Tesla and Toyota recording the largest number of vehicle sales.[6] Sales of plug-in hybrid and battery electric vehicles in 2018 rose by over 80% from the previous year, bringing the total sales of plug-in vehicles since 2010 to just over 1 million.[7] The plug-in hybrid and battery electric share of the U.S. light vehicle market in 2018 was 2.1%.[8]

[5] U.S. Department of Energy, Alternative Fuels Data Center, at https://www.afdc.energy.gov/vehicles/electric_basics_ev.html.

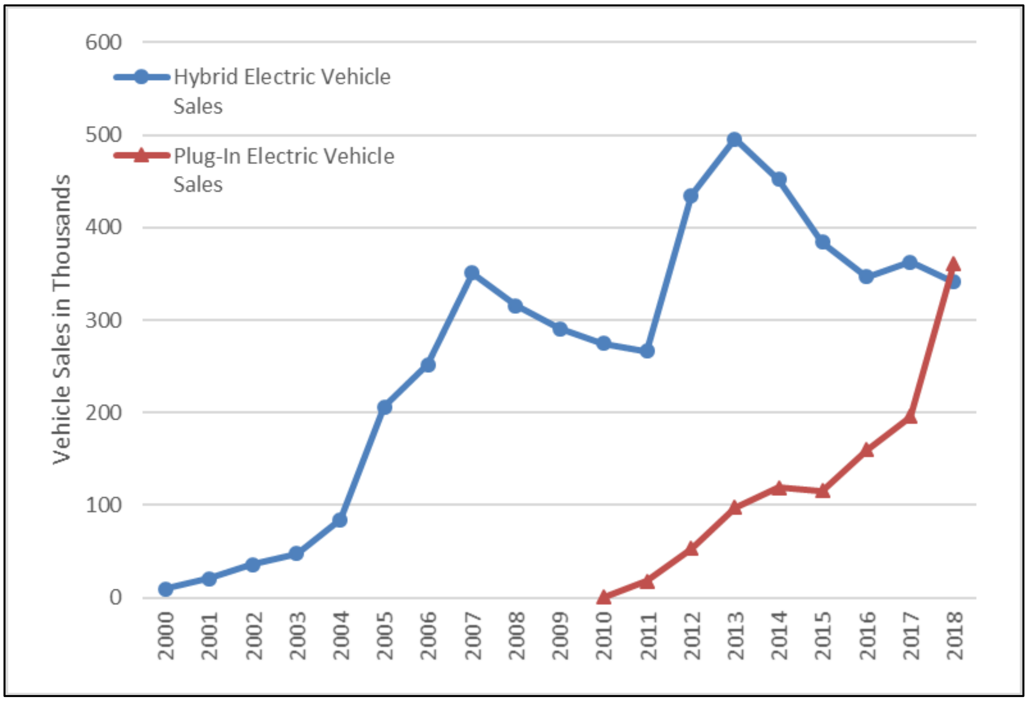
[6] CRS analysis shows that of the 42 models sold domestically, 10 were produced at seven U.S. plants, with the remainder imported.

[7] U.S. Department of Energy, "One Million Plug-in Vehicles Have Been Sold in the United States," press release, November 26, 2018, at https://www.energy.gov/eere/vehicles/articles/fotw-1057-november-26-2018-one-million-plug-vehicles-have-been-sold-united.

[8] CRS calculations based on Oak Ridge National Laboratory data; Oak Ridge National Laboratory, *Transportation Energy Data Book*, Table 6.2, at https://cta.ornl.gov/data/chapter6.shtml.

Figure 1. U.S. Annual Hybrid Electric Vehicle and Plug-In Electric Vehicle Sales

2000-2018



Source: Oak Ridge National Laboratory (ORNL), *Transportation Energy Data Book*, Table 6.2, at https://cta.ornl.gov/data/chapter6.shtml. 2018 data based on CRS calculations of unpublished ORNL data.

Notes: The total for plug-in electric vehicles includes plug-in hybrids and battery electric vehicles. Plug-in vehicle sales include only those vehicles certified for highway use.

The price of new electric vehicles is one factor inhibiting faster adoption. For example, the Leaf, a battery electric vehicle produced by Nissan, has a manufacturer's suggested retail price (MSRP) of $29,990, whereas the Nissan Sentra, a conventional vehicle similar in size and specifications to the Leaf, has an MSRP of $17,990. A smaller, less powerful vehicle with an internal combustion engine, the Nissan Versa, has an MSRP of $12,360; no electric counterpart is available in this price range. Electric vehicles are generally more expensive because of the high cost of producing the lithium-ion batteries that power them.[9]

The federal government has supported vehicle electrification in several ways. There have been tax incentives for the purchase of vehicles as well as for construction of vehicle infrastructure, such as charging stations. Federal research and development investments have sought to reduce battery costs, increase vehicle range, and decrease charging times. The federal government has also made other investments to build out EV infrastructure.

[9] Similar pricing differences exist with other manufacturers: The manufacturer's suggested retail price (MSRP) for a model year 2019 Chevrolet Cruze is $17,995. The MSRP for a model year 2019 Chevrolet Bolt EV (not including a tax credit and including some additional standard features) is $36,620. The MSRP comparison does not take into account the difference in operating costs over the lifetime of the vehicles, which may favor electric vehicles.

Federal Tax Incentives for Electrification

Two types of tax incentives have been used to promote electric vehicles: consumer incentives for the purchase of plug-in electric vehicles and individual and business incentives to install electric-vehicle charging stations to expand the charging network.

Tax Credits for Vehicle Purchases

The credit for plug-in electric vehicles (Internal Revenue Code [IRC] §30D) is the primary federal tax incentive for electric vehicles.[10] The credit ranges from $2,500 to $7,500 per vehicle, depending on the vehicle's battery capacity. The tax credit is not a function of the vehicle's price. Therefore, the subsidy amount is larger (as a percentage of a vehicle's price) for less-expensive vehicles. Generally, taxpayers claim tax credits for vehicle purchases. If the purchaser or lessee is a tax-exempt organization, the seller of the vehicle may be able to claim the credit.

The plug-in electric vehicle credit begins phasing out after a vehicle manufacturer has sold 200,000 qualifying vehicles for use in the United States. General Motors (GM) and Tesla have reached the 200,000-vehicle limit, and tax credits for their vehicles have begun to phase down.[11]

Empirical studies have found that tax incentives lead to increased EV purchases.[12] However, particularly for higher-income taxpayers, the tax credit may be claimed for purchases that would have occurred absent a federal tax incentive. Some studies have also found that incentives given closer to the point of sale, such as a rebate given at the time of purchase, are more effective in stimulating vehicle sales than tax credits.[13]

[10] See also CRS In Focus IF11017, *The Plug-In Electric Vehicle Tax Credit*, by Molly F. Sherlock.

[11] Internal Revenue Service, "First Plug-In Electric Vehicle Manufacturer Crosses 200,000 Sold Threshold; Tax Credit for Eligible Consumers Begins Phase Down on Jan. 1," press release, December 14, 2018, at https://www.irs.gov/newsroom/first-plug-in-electric-vehicle-manufacturer-crosses-200000-sold-thresholdtax-credit-for-eligible-consumers-begins-phase-down-on-jan-1; and Internal Revenue Service, "Plug-In Electric Vehicle Manufacturer Crosses 200,000 Sold Threshold; Tax Credit for Eligible Consumers Begins Phase Down on April 1," press release, March 26, 2019, at https://www.irs.gov/newsroom/plug-in-electric-vehicle-manufacturer-crosses-200000-sold-threshold-tax-credit-for-eligible-consumers-begins-phase-down-on-april-1. Tesla vehicles will be eligible for a $3,750 credit until June 30, 2019, and then for a $1,875 credit until the end of 2019. See Tesla, "Electric Vehicle & Solar Incentives," at https://www.tesla.com/support/incentives. GM electric vehicles were eligible for the full $7,500 credit until March 31, 2019, and will be eligible for a $3,750 credit until September 30, 2019, and a $1,875 credit until March 31, 2020. See Chevrolet, "Bolt EV," at https://www.chevrolet.com/electric/bolt-ev-electric-car.

[12] See, for example, Alan Jenn, Katalin Springel, and Anand R. Gopal, "Effectiveness of Electric Vehicle Incentives in the United States," *Energy Policy*, vol. 119 (2018), pp. 349-356. That study found that every $1,000 in tax credits or rebates is associated with a 2.6% increase in EV sales. See also Jianwei Xing, Benjamin Leard, and Shanjun Li, *What Does an Electric Vehicle Replace?*, National Bureau of Economic Research (NBER) Working Paper 25771, April 2019, at https://www.nber.org/papers/w25771. That study found that in 2014, the federal income tax credit for EVs led to a 28.8% increase in EV sales. For surveys of the literature, see Yan Zhou, Todd Legin, and Steven E. Plotkin, *Plug-In Electric Vehicle Policy Effectiveness: Literature Review*, Argonne National Laboratory, ANL/ESD-16/8, May 2016; and Scott Hardman, Amrit Chandan, Gil Tal, and Tom Turrentine, "The Effectiveness of Financial Purchase Incentives for Battery Electric Vehicles—A Review of the Evidence," *Renewable and Sustainable Energy Reviews*, vol. 80 (2017), pp. 1100-1111. Shanjun Li, Lang Tong, Jianwei Xing, and Yiyi Zhou, "The Market for Electric Vehicles: Indirect Network Effects and Policy Design," *Journal of the Association of Environmental and Resource Economists*, March 2017, pp. 89-133, found that between 2011 and 2013, the federal tax credits contributed to about 40% of EV sales.

[13] Easwaran Narassimhan and Caley Johnson, "The Role of Demand-Side Incentives and Charging Infrastructure on Plug-In Electric Vehicle Adoption," *Environmental Research Letters*, vol. 13 (2018), pp. 1-11. That study found that a 1% increase in tax incentives relative to a vehicle's price was associated with a 1.15% to 2.91% increase in purchases,

The Joint Committee on Taxation (JCT) projects that the plug-in electric vehicle credit will reduce federal tax revenues by $7.5 billion between FY2018 and FY2022.[14] Any extensions to or expansions of the credit could increase this amount. About half of the forgone revenue is from credits claimed on corporate tax returns.[15] Additionally, the tax credits tend to be claimed by higher-income taxpayers. For 2016, 78% of the claimants filed returns with adjusted gross income (AGI) of $100,000 or more, and such returns accounted for 83% of the amount claimed.[16] (By comparison, of all returns filed, about 17% have AGI above $100,000.)

Legislation has been introduced in the 116th Congress that would modify the plug-in electric vehicle tax credit. Some bills propose expanding the credit. For example, the Driving America Forward Act (S. 1094/H.R. 2256) would increase the per-manufacturer cap to 600,000 vehicles and modify the credit during the phase-out period. The Electric Credit Access Ready at Sale (Electric CARS) Act of 2019 (S. 993/H.R. 2042) would extend the credit through December 31, 2029, and would also allow the credit to be transferred to the financing entity.

Other proposals would eliminate the credit. The Fairness for Every Driver Act (S. 343/H.R. 1027) would eliminate the credit and impose federal highway user fees on alternative fuel vehicles.[17]

Tax Incentives for Infrastructure

The primary federal tax incentive for EV infrastructure has been the tax credit for alternative fuel vehicle refueling property (IRC §30C), which expired in 2017. The credit was generally 30% of the cost of qualified property, with the credit limited to $30,000 for businesses at each separate location and $1,000 for property installed at a taxpayer's primary residence. For property sold to a tax-exempt entity, such as a school or a hospital, the seller of the property may have been able to claim the credit. Qualifying property included electric charging infrastructure as well as other forms of clean-fuel refueling property.

The credit for alternative fuel vehicle refueling property has been a temporary tax credit since first enacted in 2005. The credit has been extended six times, often retroactively. The credit most recently expired at the end of 2017, but could be extended again.[18] The uncertainty surrounding temporary tax incentives that are often retroactively reinstated diminishes their effectiveness as an investment incentive.[19] The Electric CARS Act of 2019 (S. 993/H.R. 2042) would extend the credit through 2029.

depending on the model specification.

[14] Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2018-2022*, JCX-81-18, October 4, 2018.

[15] When a corporation claims the tax credit, it does not necessarily receive the full benefit. Ultimately, the incidence of the tax credits—the distribution of the benefits—depends on the relative responsiveness of sellers and buyers to changes in price. Tax credits claimed by sellers can be passed forward to buyers via lower prices. Conversely, sellers can raise prices to capture a portion of tax credits given to buyers.

[16] Internal Revenue Service, *SOI Tax Stats—Individual Statistical Tables by Size of Adjusted Gross Income*, "Table 3.3: All Returns: Tax Liability, Tax Credits, and Tax Payments, by Size of Adjusted Gross Income, Tax Year 2016 (Filing Year 2017)," at https://www.irs.gov/statistics/soi-tax-stats-individual-statistical-tables-by-size-of-adjusted-gross-income.

[17] Electric vehicle users do not pay into the Highway Trust Fund, which is funded by fuel taxes. See "EVs and Federal Highway Taxes " for more information.

[18] For more information, see CRS Report R45347, *Tax Provisions That Expired in 2017 ("Tax Extenders")*, by Molly F. Sherlock; and CRS Report R44990, *Energy Tax Provisions That Expired in 2017 ("Tax Extenders")*, by Molly F. Sherlock, Donald J. Marples, and Margot L. Crandall-Hollick.

[19] The credit was temporarily larger in 2009 and 2010. The American Recovery and Reinvestment Act of 2009 (P.L.

Data are not available on how much of the revenue loss associated with this provision is for EV infrastructure. The most recent one-year extension of this incentive, for all types of alternative fuel refueling property,[20] was estimated to reduce federal tax revenues by $67 million over the 10-year budget window.[21] Making the credit permanent for all types of qualifying property would reduce federal revenue by an estimated $332 million between FY2018 and FY2027.[22]

Types of Electric Chargers

Level 1 charging allows vehicles to be charged using 120-volt service, but is slow, with vehicles needing to charge for at least 10 hours to supply 80 miles of range. Often installed in car owners' garages for overnight home charging, they cost about $300, not including installation; however, a standard 120-volt electrical outlet in a residential garage can provide the same charge, and a special charger is not necessary.

Level 2 charging requires a special charging unit and access to 240-volt service, and is faster, with one to six hours of charging sufficient to supply 80 miles of range. Charging units cost about $600, not including installation, and $6,000 per unit for commercial public installations.

Level 3 direct-current fast chargers (DCFCs) use up to 500 volts of direct current to supply 80 miles of range within minutes. They can cost up to $300,000 per unit, including permitting, design, and installation.

The tax credits for EV charging infrastructure that expired at the end of 2017, if extended, could support additional investment in Level 2 charging infrastructure. Expanded access to Level 2 charging at homes and workplaces could be a cost-effective solution to building out EV infrastructure in the near term. However, if electric vehicles are to be widely used for long-distance trips, a network of direct-current fast charger (DCFC) infrastructure (Level 3) is likely necessary. The tax credit is relatively small compared to the cost of a DCFC charging station. The high cost of this infrastructure, even if tax credits are extended, may continue to pose a barrier, especially if utilization rates are low.

Given the differences in the costs and benefits associated with Level 2 and DCFC chargers, tax incentives could be provided that reflect some of these differences. There are few DCFC public chargers, yet having access to such infrastructure may have strong network benefits. Broadly, access to charging infrastructure has been shown in some studies to be a driver of demand for EVs.[23] If Congress wanted to encourage greater EV use, tax credits could be designed to provide a larger incentive for investments in public DCFC infrastructure, relative to Level 2 charging stations.

111-5) temporarily increased the credit amount to 50% of the cost of qualified property. In addition, maximum credit amounts were increased to $50,000 for business property and $2,000 for nonbusiness property.

[20] Applicable fuels were electricity, natural gas, liquefied petroleum gas, hydrogen, E85, or diesel fuel blends containing a minimum of 20% biodiesel.

[21] Joint Committee on Taxation, *Estimated Budget Effects of the Revenue Provisions Contained in the "Bipartisan Budget Act of 2018,"* February 8, 2018, JCX-4-18.

[22] Joint Committee on Taxation, *Federal Tax Provisions Expired in 2017*, March 9, 2018, JCX-5-18.

[23] See Easwaran Narassimhan and Caley Johnson, "The Role of Demand-Side Incentives and Charging Infrastructure on Plug-In Electric Vehicle Adoption," *Environmental Research Letters*, vol. 13 (2018), pp. 1-11. This study found that Nissan Leaf purchases were highly correlated with access to charging infrastructure, measured as public charging stations per driver in the state. The same, however, was not found to be true for Tesla Model S purchases. Others have found that the credits for charging infrastructure are not correlated with greater EV adoption. See Alan Jenn, Katalin Springel, and Anand R. Gopal, "Effectiveness of Electric Vehicle Incentives in the United States," *Energy Policy*, vol. 119 (2018), pp. 349-356. Shanjun Li, Lang Tong, Jianwei Xing, and Yiyi Zhou, "The Market for Electric Vehicles: Indirect Network Effects and Policy Design," *Journal of the Association of Environmental and Resource Economists*, March 2017, pp. 89-133, found that, in some circumstances, it was more cost effective to subsidize EV infrastructure than to provide tax incentives for EV purchases.

Storage incentives are another policy option that could support investment in EV infrastructure. On-site battery storage systems can be installed to allow solar power to be used for EVs. Tax incentives for batteries that facilitate EV use could encourage more of this activity. The Energy Storage Tax Incentive and Deployment Act of 2019 (S. 1142/H.R. 2096) would provide an investment credit for business or home use of energy storage.

Tax-preferred bond financing options could also be used to support EV infrastructure investment.[24] State and local financing for infrastructure solely or partially dedicated to EV charging projects may use tax-exempt bonds so long as the project is classified as serving a "public purpose" as defined in the federal code (IRC §141).[25] A federal infrastructure bank or "green bank" might also be used to support EV infrastructure investment. One option to capitalize this type of bank would be to issue tax-favored bonds.

EVs and Federal Highway Taxes

Since 1956, federal surface transportation programs have been funded largely by taxes on motor fuels that flow into the highway account of the Highway Trust Fund (HTF).[26] A steady increase in the revenues flowing into the HTF due to increased motor vehicle use and occasional increases in fuel tax rates accommodated growth in surface transportation spending over several decades. In 2001, though, trust fund revenues stopped growing faster than spending. In 2008, Congress began providing Treasury general fund transfers to keep the highway account solvent.

Electric vehicles do not burn motor fuels, and hence users do not pay motor fuels taxes. Several states have imposed some form of tax or fee on electric vehicles that is dedicated to transportation, such that EV drivers also contribute to paying for highway infrastructure. Legislation has been introduced in the 116th Congress—the Fairness for Every Driver Act (S. 343/H.R. 1027)—that would, in addition to repealing the existing tax credit for plug-in electric vehicles, impose an annual fee on alternative-technology vehicles that draw power from a source not subject to fuel excise taxes.[27] This fee would be designed to compensate for plug-in electric vehicles not paying the gas tax (or other fuel excise tax). Imposing a fee on electric vehicles or other alternative vehicles would increase their cost of ownership, although as a share of the vehicle's total cost, the amount would likely be small.[28] Exempting electric vehicles from taxes or fees imposed on other types of vehicles is one option for encouraging the purchase of electric vehicles.

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[24] For a general overview of infrastructure investment financing options, see CRS Report R43308, *Infrastructure Finance and Debt to Support Surface Transportation Investment*, by William J. Mallett and Grant A. Driessen.

[25] For more information on tax-exempt bonds, see CRS Report RL30638, *Tax-Exempt Bonds: A Description of State and Local Government Debt*, by Grant A. Driessen.

[26] Fuel taxes provide as much as 90% of the Highway Trust Fund's revenue. For more information, see CRS Report R45350, *Funding and Financing Highways and Public Transportation*, by Robert S. Kirk and William J. Mallett.

[27] Under the Fairness for Every Driver Act, a federal "alternative fuel vehicle highway user fee" would be imposed on each vehicle's owner, who would pay the fee when filing annual federal income taxes.

[28] A fee for electric vehicles could be designed to raise an amount of revenue similar to what each conventional vehicle pays in federal motor fuel excise taxes per year. Light duty vehicles consumed an average of 522 gallons in 2016. If this consumption was taxed at 18.3 cents per gallon, federal revenue raised was $95.50 per vehicle. For fuel consumption statistics, see Federal Highway Administration, *Highway Statistics 2016*, "Annual Vehicle Distance Traveled in Miles and Related Data—2016, by Highway Category and Vehicle Type," revised May 2018, at https://www.fhwa.dot.gov/policyinformation/statistics/2016/vm1.cfm.

Research and Development Priorities

Investment in transportation electrification R&D is one approach to reducing the overall cost of electric vehicle technologies. The Obama Administration made vehicle electrification a national goal—including increased spending on battery R&D, stimulus funding for construction of battery manufacturing plants in the United States, and development of DOE electric vehicle research and demonstration programs such as the "EV Everywhere Grand Challenge."[29] The Trump Administration requested reductions in funding levels for vehicle technologies R&D for FY2018 and FY2019, but Congress instead increased the program's funding levels for those years.

Federal R&D funding for electric vehicles and electric vehicle charging infrastructure is primarily administered through the DOE's Office of Energy Efficiency and Renewable Energy (EERE).[30] Within EERE, the Office of Transportation oversees the sustainable transportation R&D portfolio, which includes R&D programs in vehicle technologies, bioenergy technologies, and hydrogen and fuel cell technologies. Activities related to electric vehicles and charging infrastructure are within the Vehicle Technologies Office.

In the 116th Congress, some legislative proposals would support R&D programs. The Vehicle Innovation Act of 2019 (S. 1085/H.R. 2170) would authorize R&D programs and other activities to develop innovative vehicle technologies (including electric vehicles and charging infrastructure).

Appropriations for Electric Vehicle Research

Congress provides funding for electric vehicle technologies R&D through annual appropriations to EERE in the Energy and Water Development appropriations bill. The Trump Administration's budget request for EERE was $343 million for FY2020, $2,036 million (86%) less than the FY2019 enacted level of $2,379 million[31] (**Table 1**). The budget request, which "focuses DOE resources toward early-stage R&D and reflects an increased reliance on the private sector to fund later-stage research, development, and commercialization of energy technologies," would provide $73.4 million to vehicle technologies for FY2020, $279.6 million (79%) less than the $344

[29] In his 2011 State of the Union address, President Obama called for 1 million plug-in electric vehicles on the road by 2015; that objective was met in 2018. The Obama Administration goals were outlined in U.S. Department of Energy, *One Million Electric Vehicles by 2015: February 2011 Status Report*, p. 2, at https://www1.eere.energy.gov/vehiclesandfuels/pdfs/1_million_electric_vehicles_rpt.pdf. The DOE program was announced by President Obama in March 2012 with a goal for the United States to be the first country to build plug-in electric vehicles affordable for the average U.S. family by 2022. U.S. Department of Energy, *EV Everywhere: Grand Challenge Blueprint*, January 31, 2013, at https://www.energy.gov/sites/prod/files/2014/02/f8/eveverywhere_blueprint.pdf.

[30] EERE supports renewable energy and end-use energy efficiency technology research, development, and implementation. EERE is led by the Assistant Secretary for Energy Efficiency and Renewable Energy, and it is organized into four offices: Office of Transportation, Office of Renewable Power, Office of Energy Efficiency, and Office of Operations. DOE was established under the Department of Energy Organization Act of 1977 (P.L. 95-91). Section 203 of the act specifies eight assistant secretary positions, whose functions may be assigned by the Secretary of Energy. DOE, Energy Efficiency and Renewable Energy, "Office of Energy Efficiency and Renewable Energy Organization Chart," January 17, 2019, at https://www.energy.gov/eere/downloads/office-energy-efficiency-and-renewable-energy-organization-chart.

[31] President Trump submitted his FY2020 detailed budget proposal to Congress on March 18, 2019 (after submitting a general budget overview on March 11), and DOE released a detailed FY2020 budget request in March 2019. The budget request for EERE can be found in DOE, *FY 2020 Congressional Budget Justification*, vol. 3, part 2, March 2019, at https://www.energy.gov/sites/prod/files/2019/04/f61/doe-fy2020-budget-volume-3-Part-2.pdf (hereinafter "DOE, *FY 2020 Budget Justification*, vol. 3, part 2").

million that was directed to vehicle technologies within the Joint Explanatory Statement of the FY2019 appropriations conferees.[32]

Table 1. EERE FY2016-FY2019 Enacted Appropriations and FY2020 Request

(in millions of current dollars)

	Enacted				Request
	FY2016	**FY2017**	**FY2018**	**FY2019**	**FY2020**
EERE, Total	*2,069.2*	*2,090.2*	*2,321.8*	*2,379.0*	*695.6*
Sustainable Transportation	**636.0**	**613.0**	**674.0**	**690.0**	**163.5**
Vehicle Technologies	310.0	307.0	337.5	344.0	68.5
Bioenergy Technologies	225.0	205.0	221.5	226.0	37.0
Hydrogen and Fuel Cell Technologies	101.0	101.0	115.0	120.0	58.0

Source: P.L. 115-244 Division A explanatory statement; P.L. 115-31 Division D explanatory statement.

Note: EERE = DOE's Office of Energy Efficiency and Renewable Energy.

The FY2019 joint explanatory statement included support for various vehicle technologies to advance transportation electrification research:

- $163.2 million for the battery and electrification technologies subprogram ($38.1 million for electric drive research and development—including $7 million to enable extreme fast charging and advanced battery analytics);
- $10 million for continued funding of Section 131 of the 2007 Energy Independence and Security Act (P.L. 110-140) for transportation electrification; and
- $37.8 million for the Clean Cities program, which provides competitive grants to support alternative fuel, infrastructure, and vehicle deployment activities.

According to the FY2020 DOE budget request, the vehicle technologies program has set goals that "are necessary for new technology options to be more efficient and at least as affordable compared to [the] baseline while also accounting for consumer pay-back period expectations."[33] To advance vehicle electrification, DOE established the following research priorities:

- identify new battery chemistry and cell technologies with the potential to reduce the cost of electric vehicle batteries by more than half, to less than $100 per kilowatt hour (kWh) (with an ultimate goal of $80/kWh);
- increase vehicle range to 300 miles; and
- decrease charge time to 15 minutes or less by 2028.[34]

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[32] DOE, FY 2020 Budget Justification, vol. 3, part 2, p. 9; Joint Explanatory Statement of the Committee of Conference on H.R. 5895, Division A—Energy and Water Development and Related Agencies Appropriations Act, 2019.

[33] DOE considers the "baseline" lifecycle cost of a future (circa 2030) modeled conventional gasoline internal combustion engine vehicle to be approximately 27 cents per mile and 4,700 Btu per mile. This baseline establishes a common metric for research programs within Sustainable Transportation for comparison; see DOE, *FY2020 Budget Justification*, vol. 3, part 2, p. 17.

[34] DOE, *FY2020 Budget Justification*, vol. 3, part 2, p. 18. For reference, a survey found that commercially available lithium-ion battery packs in 2018 ranged in price between $126/kWh to $460/kWh with a volume-weighted average of

The request for FY2020 would reduce funding and prioritize "early-stage activities," including the development of critical materials-free battery technologies. The request would eliminate funding for battery safety testing, battery thermal performance testing, and Clean Cities coalition support, training and technical assistance, and partnership activities.[35]

Clean Cities Program

The DOE Clean Cities program supports local actions to reduce petroleum use in transportation.[36] The program funds transportation projects nationwide through a competitive application process, and leverages these funds with additional public- and private-sector matching funds and in-kind contributions.[37] While the program supports a variety of alternative fuels and vehicles in an effort to reduce petroleum use, funding opportunities by Clean Cities that directly support EVs include the EV Everywhere Plug-In Electric Vehicle Local Showcases.[38]

EV Everywhere Plug-In Electric Vehicle Local Showcases were selected in 2016 and are in progress. The three projects were selected to promote and demonstrate plug-in electric vehicle (PEV) use by "establishing local showcases that provide a hands-on consumer experience and in-depth education in a conveniently located, brand-neutral setting."[39] The awardees plan to establish showcases in at least 14 states, including states in the Upper Midwest, California, the Pacific Northwest, and New England.

In the FY2019 joint explanatory statement, Congress directed DOE "to continue to support the Clean Cities program, including competitive grants to support alternative fuel, infrastructure, and vehicle deployment activities."[40] In the FY2020 budget request, the Trump Administration proposed eliminating funding for the Clean Cities program.[41] In the 116th Congress, two bills that pertain to electric vehicles would establish competitive grant programs within the Department of Transportation for electric vehicle charging infrastructure (H.R. 2616 and S. 674).

$176/kWh; see James Frith, *2018 Lithium-Ion Battery Price Survey*, BloombergNEF, December 19, 2018, p. 2.

[35] DOE, *FY2020 Budget Justification*, vol. 3, part 2, pp. 20, 46.

[36] Office of Energy Efficiency and Renewable Energy, *Clean Cities: Building Partnerships to Cut Petroleum Use in Transportation*, DOE/GO-102015-4743, November 2015, at https://www.afdc.energy.gov/uploads/publication/clean_cities_overview.pdf.

[37] Since 1993, the program has funded nearly 600 transportation projects and distributed approximately $400 million in project awards. These funds have leveraged nearly $800 million in additional public- and private-sector matching funds and in-kind contributions; see DOE, Energy Efficiency and Renewable Energy, Clean Cities Coalition Network, "Goals and Accomplishments," at https://cleancities.energy.gov/accomplishments/.

[38] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Clean Cities Coalition Network, "Funded Projects," at https://cleancities.energy.gov/partnerships/projects. In addition to the EV Everywhere Plug-In Electric Vehicle Local Showcase, the Electric Vehicle Community Readiness program provided one-time funding of $8.5 million in 2011 to 16 projects to help communities prepare for plug-in electric vehicles and charging infrastructure. As part of the readiness program, community partnerships collaborated on plans to deploy EVs, including activities such as streamlining permitting processes, revising building codes, training emergency personnel, educating the public, and developing incentives. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Alternative Fuels Data Center, "Plug-In Vehicle Readiness," at https://afdc.energy.gov/pev-readiness.html.

[39] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Clean Cities Coalition Network, "Funded Projects," at https://cleancities.energy.gov/partnerships/projects.

[40] Joint Explanatory Statement of the Committee of Conference on H.R. 5895, Division A—Energy and Water Development and Related Agencies Appropriations Act, 2019.

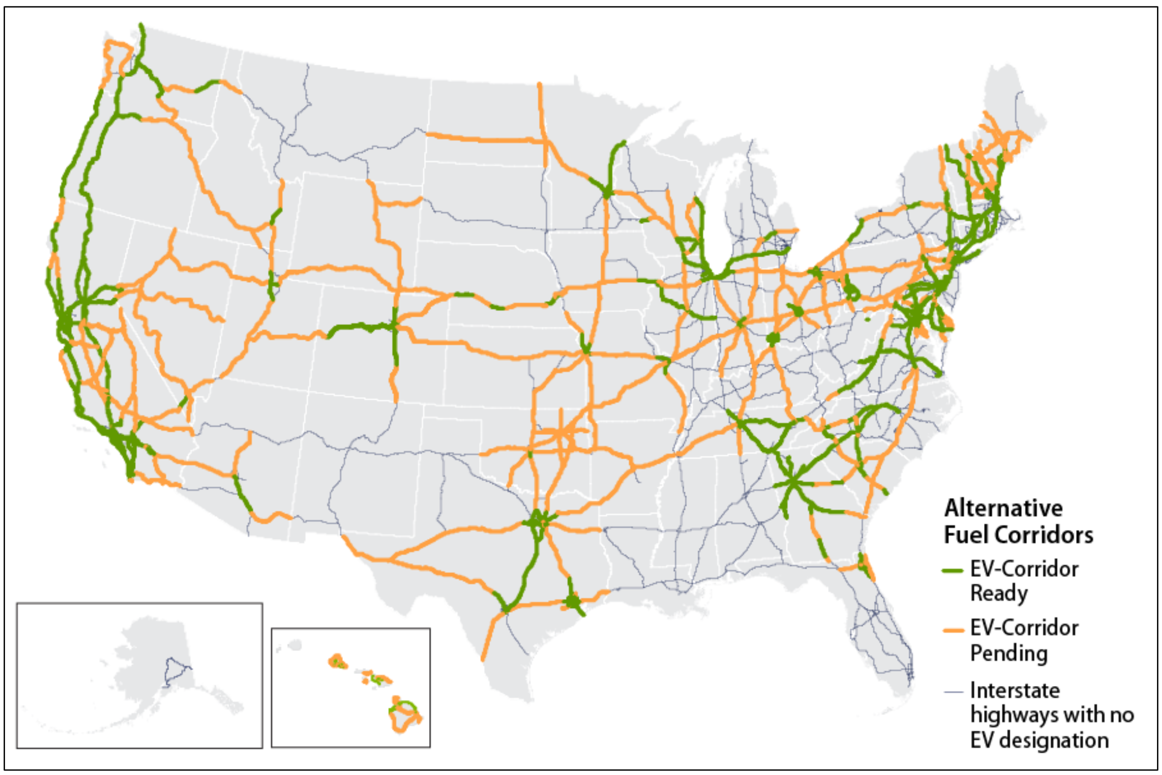
[41] DOE, *FY2020 Budget Justification*, vol. 3, part 2, p. 46.

Alternative Fuel Corridors

Purchases of electric vehicles in the near future will depend to some extent on the steps state and local governments and private entities take to build a reliable network of charging stations. Section 1413 of the Fixing America's Surface Transportation Act (FAST Act; P.L. 114-94) seeks to address that goal; it requires the Department of Transportation (DOT) to designate by 2020 national alternative fuel corridors (AFCs) to promote vehicle use of electricity, hydrogen, propane, and natural gas. The Federal Highway Administration (FHWA) has been working with other federal, state, and local officials and industry groups to plan AFC designations on interstate corridors (**Figure 2**). FHWA has assigned designations to highways as either "corridor ready"—they have enough fueling stations to serve a corridor—or "corridor pending," where alternative fueling is insufficient. In the case of electric vehicles, a corridor-ready designation would apply if there were EV charging stations at 50-mile intervals, with a goal of establishing Level 3 DC Fast Charge infrastructure.

Figure 2. Alternative Fuel Corridors for Electric Vehicles

Corridors in 2019



Source: CRS map based on Federal Highway Administration data at https://hepgis.fhwa.dot.gov/fhwagis/ViewMap.aspx?map=Highway+Information|Electric+Vehicle+(EV-Round+1,+2+and+3)#.

Notes: States can designate portions of highways in their jurisdiction as alternative fuel corridors, subject to approval by FHWA, which approved Rounds 1, 2, and 3 of such designations in 2016, 2017, and 2018. These rounds have resulted in corridors that are designated as "ready" or "pending," categories based on the maximum distance between fueling stations. For example, if EV charging stations are more than 50 miles apart, that portion of highway is designated "pending."

Under this program, FHWA has developed standardized AFC signage and other forms of public education, and encouraged regional cooperation in planning new fueling networks. FHWA has undertaken three rounds of AFC nominations, the latest announced in April 2019. FHWA has identified building out alternative corridors on the most traveled Interstates, such as I-95 and I-80, as priorities for third-round funding. An additional goal is to secure nominations for areas targeted for EV investments by Electrify America in its Zero Emission Vehicle (ZEV) investment plan.[42]

Signage and installation of alternative fueling infrastructure along these corridors have been determined to be eligible expenses under FHWA's Congestion Mitigation and Air Quality Improvement (CMAQ) Program.[43] In addition, the Department of Energy's Clean Cities program provides funding for fueling infrastructure, and some states have similar programs.

Federal Support for Municipal Bus Electrification

Until recently, the operation of battery electric buses in U.S. cities was seen as a long-term prospect because of their relatively high cost, range limits, and recharging infrastructure needs. But with technological improvements, public transportation agencies have begun to show interest in electric buses to replace vehicles powered by diesel and other fossil fuels. This interest is especially strong in metropolitan areas with air quality problems. The Federal Transit Administration (FTA) provides substantial support to transit agencies to purchase buses. Federal funds can be spent on most types of bus technology; the choice of technology is up to the transit agency concerned.

Transit buses typically operate over short distances with fixed routes and frequent stops. In 1996, 95% of the buses in service were powered by diesel fuel (**Figure 3**). More recently, transit agencies have integrated buses fueled by compressed natural gas (CNG), liquefied natural gas (LNG), and biodiesel into their fleets. Since the end of the last recession, the share of lower-emission hybrid buses—including diesel buses with electric motors—has also increased, rising from just under 5% of buses in use in 2009 to nearly 15% in 2016. Diesel-electric buses are powered by both an electric motor and a smaller-than-normal internal combustion engine; regenerative braking systems store energy from use of the bus's mechanical systems, giving the bus greater range. The purchase price of hybrids is less expensive than a fully electric bus, and hybrids reduce emissions compared to conventional diesel buses.[44]

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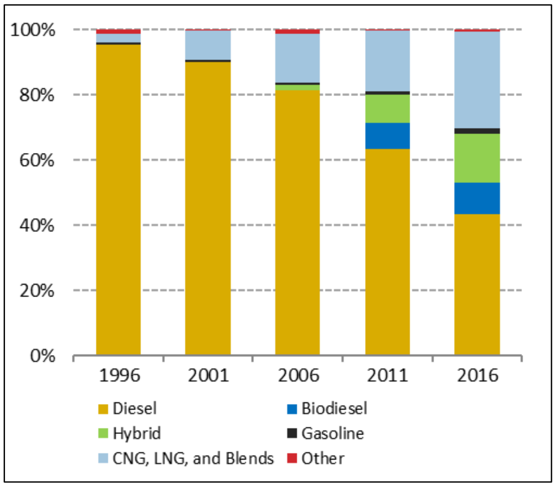
[42] Electrify America was formed in 2016 as part of Volkswagen Group's settlement with the U.S. Department of Justice. It is a subsidiary of Volkswagen Group.

[43] Program descriptions provided to CRS in FHWA email of November 5, 2018; also, see Federal Highway Administration, "Interim Program Guidance Under MAP-21," November 12, 2013, at https://www.fhwa.dot.gov/environment/air_quality/cmaq/policy_and_guidance/2013_guidance/index.cfm. In addition, the Manual on Uniform Traffic Control Devices (MUTCD) provides guidance on signage design and placement. See Federal Highway Administration, "Signing for Designated Alternative Fuels Corridors," in *Manual on Uniform Traffic Control Devices (MUTCD)*, at https://mutcd.fhwa.dot.gov/resources/policy/alt_fuel_corridors/index.htm.

[44] Carnegie Mellon University, Scott Institute for Energy Innovation, *Which Alternative Fuel Technology Is Best for Transit Buses?*, January 2017, p. 19, at https://www.cmu.edu/energy/education-outreach/public-outreach/17-104%20Policy%20Brief%20Buses_WEB.pdf.

Figure 3. U.S. Transit Buses by Fuel Type



Source: CRS, based on U.S. Department of Energy, Alternative Fuels Data Center, and American Public Transportation Association (APTA) Fact Book and Appendix, 2017.

Notes: Data show buses in operation. "Other" includes buses propelled with electricity, hydrogen, and propane.

There were 300 battery electric buses in operation domestically at the end of 2017, less than 0.5% of the 65,000 buses in public transit agencies' fleets. However, the two biggest transit bus systems in the United States, Los Angeles Metro and New York City Transit, have announced plans to move to zero-emission bus fleets, most likely using battery electric buses, by 2030 and 2040, respectively.[45]

Electric buses are typically expensive to purchase, costing as much as $300,000 more than conventional diesel buses, and require additional investment to build recharging infrastructure. On the other hand, electric buses are quieter than internal combustion engine vehicles, may have lower operating costs due to the absence of engines and transmissions requiring maintenance, and have low or zero direct emissions. The range an electric bus can travel on one charge has in the past been a limiting factor, but newer models can travel more than 200 miles, still short of the 600-mile or more range that conventional and other alternative fuel buses can travel.[46] A study by Carnegie Mellon University found that when social costs, such as the health effects of diesel emissions, are taken into account, battery electric buses have lower total annualized costs than conventional diesel buses over the typical 12-year life cycle of a transit bus.[47]

Electric buses are generally eligible for FTA funding under several programs, including the Bus and Bus Facilities Program.[48] One discretionary component of the FTA bus program is the Low or No Emission Vehicle (Low-No) program, which provides funding to state and local authorities for the purchase or lease of zero-emission and low-emission transit buses as well as acquisition, construction, and leasing of required supporting facilities. Electric buses are purchased through the Low-No bus program; mandatory spending of $55 million per year through FY2020 was authorized in the FAST Act. An additional $29.5 million was appropriated for FY2018.

[45] Los Angeles County Metropolitan Transportation Authority, "Metro Leads the Nation in Setting Ambitious 2030 Zero Emission Bus Goal," press release, August 2, 2017, at https://www.metro.net/news/simple_pr/metro-leads-setting-2030-zero-emission-bus-goal/; and New York Metropolitan Transportation Authority (MTA), *MTA Board Meeting*, April 25, 2018, remarks by Andy Byford, president of New York City Transit Authority, at 1:17:14 in the following video of the MTA board meeting: https://www.youtube.com/watch?v=3u2Z35Awh84.

[46] According to the Carnegie Mellon University study, 40-foot buses have typical ranges of 600 miles for compressed natural gas, 690 miles for diesel, and 720 for hybrid-electric. Carnegie Mellon University Scott Institute for Energy Innovation, *Policymaker Guide: Which Alternative Fuel Technology is Best for Transit Buses?*, January 2017, p. 15.

[47] In the Carnegie Mellon University study, total annualized costs per bus are determined by summing life cycle agency costs (such as bus purchase costs, fuel costs, and operation and maintenance costs) with social costs (such as costs from climate change and air pollution). Carnegie Mellon University, Scott Institute for Energy Innovation, *Which Alternative Fuel Technology Is Best for Transit Buses?*, January 2017, p. 18.

[48] The FTA Bus and Bus Facilities Program primarily distributes funds to local transit systems by formula.

School buses generally have diesel engines, and they are primarily funded locally. FTA does not fund school buses, but the Environmental Protection Agency (EPA) administers the School Bus Rebate Program, which assists school districts in reducing diesel emissions. In 2017, nearly $9 million was provided to replace diesel buses with diesel-electric hybrids.[49]

In the 116th Congress, some legislative proposals would support vehicle fleet electrification, including transit buses. The Green Bus Act of 2019 (H.R. 2164) would require that any bus purchased or leased with funds provided by the Federal Transit Administration for public transportation purposes be a zero-emission bus. The Federal Leadership in Energy Efficient Transportation (FLEET) Act (H.R. 2337) would authorize the U.S. Postal Service to enter into energy savings performance contracts to purchase or lease low-emission and fuel-efficient vehicles (including electric vehicles) and to construct or maintain infrastructure, including electric vehicle charging stations, among other provisions.[50]

Other Federal Policies Affecting Electrification

The following policies were generally established for purposes not directly related to vehicle electrification, but they have dimensions that may support that goal.

Volkswagen Settlement

In 2016, Volkswagen Group reached a number of legal settlements concerning violations of the Clean Air Act.[51] As part of its settlement terms, Volkswagen pledged to invest $2 billion over a 10-year period in zero-emissions vehicle infrastructure and education in select U.S. cities through its Electrify America initiative. Of that amount, $800 million is to be spent in California. As an additional condition, Volkswagen was also required to fund a $2.7 billion national Environmental Mitigation Trust, funds from which are available to states and other beneficiaries for mitigating the negative impacts of the excess diesel emissions that were released by Volkswagen's noncompliant vehicles. States could choose to spend some of this special funding on bus electrification, including school buses.

Federal Motor Vehicle Environmental Regulations

The first motor vehicle fuel economy standards were enacted in 1975 in response to the oil embargo of 1973-1974 (Energy Policy and Conservation Act of 1975; P.L. 94-163, as amended). The National Highway Traffic Safety Administration (NHTSA) sets and enforces the Corporate Average Fuel Economy (CAFE) standards for passenger cars and light trucks, which were most recently legislatively set in the Energy Independence and Security Act of 2007 (P.L. 110-140) at 35 miles per gallon (mpg) by 2020. Because EPA has authority to regulate greenhouse gas (GHG) emissions, it joined with NHTSA during the Obama Administration to promulgate new, stricter combined CAFE/GHG standards for motor vehicles. These new standards established targets for

[49] U.S. Environmental Protection Agency, "EPA School Bus Rebate Program to Reduce Diesel Emissions," press release, October 16, 2018, at https://www.epa.gov/newsreleases/epa-school-bus-rebate-program-reduce-diesel-emissions.

[50] For more information on energy savings performance contracts, see CRS Report R45411, *Energy Savings Performance Contracts (ESPCs) and Utility Energy Service Contracts (UESCs)*, by Corrie E. Clark.

[51] Environmental Protection Agency, "EPA Approved National ZEV Investment Plan," press release, April 9, 2017, at https://www.epa.gov/enforcement/epa-approved-national-zev-investment-plan-public-version; and CRS Report R44372, *Volkswagen, Defeat Devices, and the Clean Air Act: Frequently Asked Questions*, by Bill Canis et al.

reduced GHG emissions and rising CAFE fuel economy of nearly 50 mpg by model year (MY) 2025. Electrification was seen as one means of reaching the new CAFE/GHG targets.[52]

The Trump Administration has proposed to leave the current CAFE/GHG standards in place through model year 2026, based on its analysis that economic and technological factors have changed since the standards were put in place in 2010.[53] EPA asserted in April 2018 that the goals established for MY2026 could be achieved only with more extensive vehicle electrification than now anticipated, and rejected previous EPA determinations that EV sales in future years would grow rapidly enough to enable automakers to comply with the MY2022-MY2025 standards: "Based on consideration of the information provided, the Administrator believes that it would not be practicable to meet the MY 2022–2025 emission standards without significant electrification and other advanced vehicle technologies that lack a requisite level of consumer acceptance."[54]

Prospects for Electrification of Autonomous Vehicles

Fully autonomous passenger vehicles hold the potential for safer transportation and new mobility for the elderly, the disabled, and those who cannot afford to purchase a car. The projected timeline for emergence of fully autonomous vehicles varies from several years to several decades.

It is often assumed that autonomous vehicles—including those providing ride-sharing services—will employ electric motors instead of internal combustion engines, but that assumption is based on the types of federal and state policies that are put in place. In the absence of policies favoring EVs, future autonomous vehicles could be powered by fossil fuels.

There are several reasons why electrification may not be the ultimate choice for autonomous vehicles. Analyses by Ford and Volvo have for the following reasons led them to retain internal combustion engines for their ride-sharing ventures for the present: [55]

- **Expense and Inconvenience.** Electric vehicles remain expensive compared to conventional vehicles, and many models have short driving ranges and long refueling times. Shared vehicles, which may be on the road for many hours a day, magnify these shortcomings.
- **Battery Life.** Frequent use of battery fast charging is known to lead to faster degradation of the battery.
- **Energy-Intensity.** Autonomous vehicles rely on energy-intensive technologies. It has been estimated that operation of an autonomous driving system for two hours in an electric vehicle could use as much as 10% of its stored energy before the vehicle moves, requiring even more frequent recharging.

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[52] For background and analysis of these standards and Trump Administration recommendations for changes, see CRS Report R45204, *Vehicle Fuel Economy and Greenhouse Gas Standards: Frequently Asked Questions*, by Richard K. Lattanzio, Linda Tsang, and Bill Canis.

[53] NHTSA and EPA, "The Safer Affordable Fuel Efficient (SAFE) Vehicles Proposed Rule for Model Years 2012-2016," 83 *Federal Register* 42986, August 24, 2018, at https://www.govinfo.gov/content/pkg/FR-2018-08-24/pdf/2018-16820.pdf. The notice of proposed rulemaking asked for comments by October 23, 2018.

[54] EPA, "Mid-Term Evaluation of Greenhouse Gas Emissions Standards for Model Year 2022–2025 Light-Duty Vehicles," 83 *Federal Register* 16077, April 13, 2018.

[55] Peter Slowik, *The Future of Transportation: Autonomous and ... Internal Combustion?*, International Council on Clean Transportation (ICCT), January 16, 2018, at https://www.theicct.org/blog/staff/future-transportation-autonomous-internal-combustion.

These drawbacks are countered by the following factors that could make electrification of autonomous vehicles the more attractive power source:

- **Compatibility.** The extensive use of computers and sensors in autonomous vehicles may be easier to embed in electric vehicles, which have fewer mechanical—and more electronic—parts than a conventional vehicle.
- **Operability.** Electricity is generally less expensive than gasoline or diesel, and maintenance costs for electric vehicles, with many fewer parts, may be considerably lower.
- **Emissions.** The power demands of autonomous vehicle equipment and computers will reduce the fuel economy of gasoline and diesel vehicles and increase emissions. It has been estimated that increased power requirements will increase emissions from combustion vehicles by over 60 grams of CO_2 equivalent per mile, equal to reducing fuel economy of a 35 mpg vehicle to 29 mpg. Switching to electricity would diminish the direct emissions.[56]

State Incentives and Utility Issues

Acceptance of electric vehicles and related infrastructure is affected by legislation, regulations, and policies adopted by state agencies and electric utilities.

State Incentives

Incentives vary widely from state to state. The National Conference of State Legislatures tracks vehicle and charger incentives on a state-by-state basis.[57] Forty-five states and the District of Columbia currently offer incentives for certain hybrid or electric vehicles, or both. Those incentives include

- permitting solo drivers of electric and hybrid vehicles to use high-occupancy (carpool) lanes,
- income tax credits and rebates for the purchase of an electric vehicle,
- reduced registration fees,
- parking fee exemptions,
- excise tax and emission test waivers, and
- income tax credits for installation of a home or business charger.[58]

These incentives have been found to vary in their effectiveness. Several analyses have shown that tax incentives for electric vehicles and infrastructure are the "dominant factors in driving PEV adoption."[59] Rebates—which happen at the point of sale or within a short time after a vehicle

[56] David Reichmuth, *How Important Is it for Self-Driving Cars to be Electric?*, Union of Concerned Scientists, May 3, 2018, at https://blog.ucsusa.org/dave-reichmuth/how-important-is-it-for-self-driving-cars-to-be-electric.

[57] For a description of incentives in each state, see the National Conference on State Legislatures, "State Efforts to Promote Hybrid and Electric Vehicles," September 26, 2017, at http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx.

[58] For example, the Massachusetts Electric Vehicle Incentive Program provides grants of 50% of the cost, up to $25,000, to workplaces that install a charging station.

[59] Easwaran Narassimhan and Caley Johnson, "The Role of Demand-Side Incentives and Charging Infrastructure on Plug-In Electric Vehicle Adoption: Analysis of US States," IOPScience, *Environmental Research Letters*, vol. 13, no.

purchase—have been identified as the most effective incentive because their value is clear to buyers at the time of a vehicle transaction.[60]

Zero Emission Vehicle Program

The California Air Resources Board (CARB) adopted low-emission vehicle regulations in 1990, requiring automakers to sell light vehicles in that state that meet progressively cleaner emissions standards.[61] As part of these emission regulations, CARB also established the Zero-Emission Vehicle (ZEV) program, which requires automakers to offer for sale the lowest-emission vehicles available, with a focus on battery electric, plug-in hybrid electric, and hydrogen fuel cell vehicles. The number of ZEVs each automaker is required to sell is based upon its total light-vehicle sales in California. CARB has set ZEV sales percentages through a vehicle credit system, increasing annually to 2025. Nine other states have adopted the California ZEV regulations. The states affected by the regulations represent over one-third of all U.S. new light vehicle sales.[62]

Utilities and EVs and EV Infrastructure: Tax and Regulatory Issues

Electric utilities, which are regulated by the state in which they are located, are in a unique position as the primary providers of electricity to aid in integrating EVs into the grid. Utilities can provide incentives to consumers to charge EVs during off-peak hours when there is excess generation. Utilities may also be in the position to install public electric charging infrastructure, assuming that there are no limits on their owning these assets. Many of the barriers utilities face with respect to electrification infrastructure are regulatory, and the role of tax policy in addressing such barriers may be limited.

Sluggish growth in energy demand has posed a challenge for the electric utility sector. The industry has recognized EVs as an opportunity for growth. For this reason, electric utilities may have their own market-based incentives (absent federal intervention) to invest in EV infrastructure and take measures to support consumer EV adoption. Further, electric utilities may support extending current-law vehicle and infrastructure tax credits.[63] At the same time, preparing the grid for a surge in electric car ownership could require substantial capital investments, if peak demand is increased.

Tax Incentives to Utilities for Electric Vehicle Infrastructure

A number of challenges are associated with providing tax incentives to utilities that provide EV infrastructure. While 65% of electricity customers across the United States are customers of investor-owned utilities, most other users purchase electricity from cooperatives or municipal power providers. There are limited options for providing a direct federal tax benefit to

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7, July 13, 2018, p. 9, at https://iopscience.iop.org/article/10.1088/1748-9326/aad0f8.

[60] Ibid. See also Zifei Yang, Peter Slowick, and Nic Lutsey, et al., *Principles for Effective Electric Vehicle Incentive Design*, International Council on Clean Transportation (ICCT), June 2016, at https://www.theicct.org/publications/principles-effective-electric-vehicle-incentive-design.

[61] California Air Resources Board, *Zero-Emission Vehicle Program*, viewed May 13, 2019, at https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program/about.

[62] The Clean Air Act enables other states to adopt California's standards. The nine states are Connecticut, Maine, Maryland, Massachusetts, New York, New Jersey, Oregon, Rhode Island, and Vermont.

[63] Samantha Raphelson, "U.S. Utilities Look to Electric Cars as Their Savior Amid Decline in Demand," NPR, March 2018, at https://www.npr.org/2018/03/29/598032288/u-s-utilities-look-to-electric-cars-as-their-savior-amid-decline-in-demand.

cooperative or municipal utilities that do not pay federal income taxes.[64] Further, in many states customers may purchase electricity from competing suppliers and pay the local electric utility for delivering it.[65] A tax incentive to provide EV infrastructure might be made available only to utilities, to other electricity suppliers, or to both. Applicability of such an incentive would vary according to state policies or the type of utility.[66]

State regulatory commissions typically establish prices or rates that allow utilities to earn a rate of return that the regulator determines to be reasonable. This rate of return is fixed, such that additional tax incentives do not necessarily increase the return that a utility can realize. Federal taxes are an operating expense. In some states, tax incentives that reduce utilities' operating expenses result in lower rates for electricity customers (not higher returns for utilities). Hence, federal tax incentives may provide a limited near-term incentive for utilities to increase capital spending on EV infrastructure.

State Regulatory Considerations

In the United States, the sale of electricity is governed by many different federal, state, and local regulations. When it comes to the sale of electricity for the purpose of charging EVs, the states generally have regulatory jurisdiction over retail electricity transactions,[67] though federal and municipal authorities may also play a role.[68] State approaches to regulation vary considerably.

Rules and regulations governing the retail sale of electricity generally originate with a state public utility commission. An electric utility is defined in federal law as any person, state, or federal agency "which sells electric energy."[69] This definition could potentially be interpreted to mean that electric vehicle charging station operators are electric utilities by virtue of the fact that they sell electricity, and are therefore subject to all laws, requirements, and regulations pertaining to electric utilities.

Should charging station operators be subject to regulation as electric utilities, or is regulatory reform necessary to accommodate this new class of electricity transactions? Faced with the question of whether or how to regulate the operators, states have taken a variety of approaches:

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[64] Data on utility bundled sales by ownership type can be found in Table 10 U.S. Energy Information Administration, "Electric Sales, Revenue, and Average Price," at https://www.eia.gov/electricity/sales_revenue_price/.

[65] U.S. Energy Information Administration, "Power Marketers Are Increasing Their Share of U.S. Retail Electricity Sales," June 12, 2018, at https://www.eia.gov/todayinenergy/detail.php?id=36415.

[66] For example, some publicly owned utilities may not be able to take advantage of federal tax incentives.

[67] Jurisdiction over the sale of electricity to or from an EV charging station hinges upon its definition as either a retail transaction or a sale for resale. Retail transactions are generally defined by the Federal Energy Regulatory Commission (FERC) as "sales made directly to the customer that consumes the energy product," whereas sales for resale are defined as "a type of wholesale sales covering energy supplied to other electric utilities, cooperatives, municipalities, and Federal and state electric agencies for resale to ultimate consumers." (FERC, "Glossary," accessed November 6, 2018, at https://www.ferc.gov/resources/glossary.asp?csrt=17301308159773522879#R.) States typically regulate retail electricity transactions, while FERC has jurisdiction over the transmission and wholesale sales of electricity in interstate commerce. The question of how to define sales of electricity to and from charging stations (including vehicle-to-grid transactions) may be subject to significant legal interpretation, and potentially represents the intersection of various federal and state statutes and regulations. A comprehensive legal analysis is beyond the scope of this report.

[68] To date, FERC has not intervened in state decisions regarding the classification and regulation of EV infrastructure. In the absence of clear or comprehensive state policies, some cities and counties have become the de facto regulators of EV charging stations within their regions.

[69] See §3 of the Public Utility Regulatory Policies Act of 1978 (P.L. 95-617, 16 U.S.C. §2602(4)).

- Some states have issued new guidelines or regulations that define the requirements for regulated utilities to operate charging stations.[70] For example, some states (e.g., Oregon) allow existing regulated utilities to invest in and operate EV charging stations as separate, nonregulated ventures. Others (e.g., Texas) have effectively limited the operation of charging stations to electric distribution utilities by requiring operators to meet high technical and financial standards. Still others (e.g., Kansas) have prevented electric utilities from owning and operating charging stations altogether.
- Other states (e.g., New York) have exempted charging station operators from public utility regulations. This leaves questions as to which regulatory agency, if any, is responsible for regulating the charging station operators, as well as whether additional regulation is needed in order to ensure fair market practices.[71]
- Finally, some states have refrained from taking action altogether. Without regulatory changes, private charging station operators in these states may be subject to regulation as a utility by the state's public commission. Lack of clarity about how operators will be regulated is seen by some as an impediment to the spread of the technology in these states.[72] In some cases, EV service providers have avoided regulation as a utility by providing charging services for free, or by charging customers by the minute rather than by the amount of electricity used.

Whether public utilities or private companies may operate electric vehicle charging stations and whether station operators are subject to regulation as a utility may affect deployment of EV charging infrastructure. State jurisdiction over retail electricity transactions may limit the potential role of the federal government in regulating the provision of EV charging services.

An additional consideration is the potential for electric vehicle batteries to be used for storage, referred to as vehicle-to-grid (V2G) storage. V2G storage would allow idle vehicle batteries to be used for grid services, such as demand response. The batteries could reduce vehicle owners' electricity demand during peak periods or provide electricity to the grid during peak periods in response to time-based rates or other financial incentives. In the United States, utilities are beginning to test V2G performance in demonstration projects.[73] In addition to technology, other identified challenges include regulation, market, and end-user acceptance.[74]

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[70] Martha Moore, "Should Utilities Build Charging Stations for Electric Cars?," Pew, Stateline (blog), September 11, 2017, at http://pew.org/2wOozZk.

[71] For a more detailed discussion of these issues, see Christopher Young, Marc Machlin, and Erica Hall Dressler, "Electric Vehicle Charging Station Regulation: Why Your Local Electric Vehicle Charging Station Doesn't (and Shouldn't) Look Like Your Local Gas Station," Client Alert (Pepper Hamilton LLP), June 23, 2016.

[72] The Council of State Governments, "State Utilities Law and Electric Vehicle Charging Stations," October 2013, at http://knowledgecenter.csg.org/kc/content/state-utilities-law-and-electric-vehicle-charging-stations.

[73] For example, Austin Energy, a publicly owned utility, through the Austin Sustainable and Holistic Integration of Energy Storage and Solar Photovoltaics (SHINES) project is reportedly testing V2G performance. Justin Gerdes, "Vehicle-to-Grid Testing Comes to Texas," *Greentech Media*, February 14, 2019, at https://www.greentechmedia.com/articles/read/vehicle-to-grid-testing-austin-energy-pecan-street#gs.c658jp.

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