THE CURRENT STATE OF ELECTRIC VEHICLE SUBSIDIES:
ECONOMIC, ENVIRONMENTAL, AND DISTRIBUTIONAL IMPACTS

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Introduction

Subsidies for electric vehicle (EV) production and consumption are often promoted as a way to reduce local air pollution, reduce carbon emissions, and boost the rate of technological innovation. Support for these ideas has been strong enough that government policies designed to encourage the adoption of electric vehicles exist at the federal, state, and local level in the United States. Despite these subsidies, for most consumers EVs remain less cost-effective than gasoline or gasoline-electric hybrid vehicles. However, declining battery prices and the promise of future innovation suggest that adoption rates may accelerate.

The total cost of subsidies for EVs in the United States is substantial, accounting for billions of dollars of government spending. Some of these policies are targeted at consumers. For example, federal and state tax credits provide consumers with a direct financial incentive to purchase these vehicles. Other policies are targeted at producers, including federal grants and loans to automakers of electric vehicles and manufacturers of EV batteries. Other implicit or explicit subsidies exist as well. Electric vehicles are often given preferential treatment with regard to high-occupancy vehicle (HOV) lanes, registration fees, or government-funded support infrastructure including charging stations.

While there are potential benefits to society from greater rates of EV adoption, there are substantial negative consequences as well. In this paper, we examine the effect of EV subsidies on the distribution of income and wealth in the United States. We also evaluate the potential for EVs to improve local air quality and reduce carbon emissions. Finally, we assess the potential for innovation spillovers from the EV industry. We begin with a brief discussion of the history and overall structure of electric vehicle policy in the United States at both the state and federal level. We also assess the literature on the benefits and costs of electric vehicle policy in the United States.

History of Electric Vehicle Subsidies

Though electric vehicles have existed for close to a century, subsidies for EVs are a relatively recent development. Most early federal and state involvement in the EV industry was research and development funding established during the oil crisis and economic downturn of the 1970s.[1] This crisis also led Congress to create Corporate Average Fuel Economy (CAFE) standards, which impose average fleet fuel efficiency standards for automakers that have become more stringent over time.[2] Because EVs generate no tailpipe emissions, an automaker can greatly improve its total average fuel efficiency by including EVs in their fleet.

Beginning in the 1990s, automakers introduced limited-range electric cars to larger markets as state governments began passing the first EV subsidies, which most often took the form of tax exemptions, HOV lane privileges, and government fleet mandates. Despite increased state subsidies and consumer interest, EVs were expensive and limited to a niche market. By the late '90s, state subsidies for electric vehicles increased as direct purchase subsidies for EVs began appearing in states across the U.S.[3] Among them were the first direct tax subsidies for the purchase of electric cars.

Despite the slow proliferation of direct and indirect subsidies, technological shortcomings and low consumer demand still limited EV sales through the mid 2000s. In 2008, the most popular electric vehicle on the market was the Toyota Prius, a hybrid that only operated on electricity when traveling below 20 mph and that came with a price tag of $21,400.[4]

1 Department of Energy (DOE). (2014, September 15). The History of the Electric Car. Retrieved from: https://energy.gov/articles/history-electric-car

2 US Department of Transportation (USDOT). (2017). Corporate Average Fuel Economy (CAFE) Standards. Retrieved from: https://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards

3 Alternative Fuels Data Center. (2017, May 21). *Federal Laws and Incentives*. Department of Energy (DOE). Retrieved from https://www.afdc.energy.gov/laws/fed_summary

4 Alternative Fuels Data Center, Department of Energy (DOE). (January, 2016). U.S. HEV Sales by Model (graph). Retrieved from https://www.afdc.energy.gov/data/10301 ; Autotrader, Inc. (2017). 2008 Toyota Prius. Retrieved from https://www.autotrader.com/2008-toyota-Prius.jsp?modelId=17262

The recession of 2008 provided a political window for EV subsidies to spread at the state and federal level. Historically high gas prices coupled with a political climate that rewarded expansionary fiscal policy meant that both public and private parties had an interest in encouraging the production and sale of EVs.[5] As a result, EV purchase subsidies were introduced at the federal level in the Energy Improvement and Extension Act of 2008 under the Bush administration. The Act, passed alongside a bundle of acts intended to mitigate the growing financial crisis, included the first direct federal subsidy for electric cars, offering tax credits of up to $7,500 for EV purchases.[6] Less than five months later, the American Recovery and Reinvestment Act (ARRA) included provisions to further fund and extend the federal EV subsidy.[7] The ARRA also provided $2 billion for research and development of electric vehicle components and $400 million toward charging infrastructure.[8]

The ambitious nature of both the subsidies and the then-new Obama Administration's promises of high electric vehicle adoption set the political course for the next eight years. During this time period, the federal government and many states introduced or increased direct subsidies for EV purchases and investment in EV infrastructure.[9]

Electric vehicle technology has advanced rapidly in the last few years. Early electric vehicles, like the General Motors EV1, had short ranges and were prohibitively expensive for automakers to produce.[10] As battery costs have declined and performance improved, electric vehicles have become more comparable to conventional vehicles. Automakers like Tesla Motors have introduced luxury electric vehicles with high speeds and longer ranges per charge, while automakers like Nissan and GM have introduced vehicles that are somewhat more affordable, though with shorter ranges.

Despite their increased upfront cost, electric vehicles may be cost-effective for some consumers.[11] Depending on the relative costs of gasoline and electricity, in certain situations electric vehicles may even be less expensive to operate in the long run than traditional gasoline vehicles, primarily because EVs tend to have lower fuel costs. By converting the amount of energy needed to travel one mile into comparable terms with gasoline, EVs are more efficient, with miles per gallon equivalent (MPGe) ratings[12] that range from 62 MPGe to 136 MPGe for EVs produced in the last decade.[13] EVs may also have lower maintenance costs relative to gasoline vehicles, as they tend to operate with simpler mechanisms with fewer moving parts.

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5 From 2001 to 2008 adjusted gas prices increased from $1.91 to $3.61 per gallon. US Department of Energy (DOE) Fact #915: March 7, 2016 Average Historical Annual Gasoline Pump Price, 1929-2015. Retrieved from: https://energy.gov/eere/vehicles/fact-915-march-7-2016-average-historical-annual-gasoline-pump-price-1929-2015

6 Energy Improvement and Extension Act. 110 U.S.C § H.R.6049. (2008, October 3). Retrieved from: https://www.congress.gov/bill/110th-congress/house-bill/6049

7 Internal Revenue Service. (August, 2017). "Plug-In Electric Drive Vehicle Credit (IRC 30D)." Retreived from: https://www.irs.gov/businesses/plug-in-electric-vehicle-credit-irc-30-and-irc-30d.

8 Department of Energy. (August, 2009). "President Obama Announces $2.4 Billion in Grants to Accelerate the Manufacturing and Deployment of the Next Generation of U.S. Batteries and Electric Vehicles." Retrieved from: https://energy.gov/articles/president-obama-announces-24-billion-grants-accelerate-manufacturing-and-deployment-next.

9 Alternative Fuels Data Center. (2017). State Laws and Incentives database. Department of Energy (DOE). Retrieved from: https://www.afdc.energy.gov/laws/state

10 Voelcker, J. (2013, October 9). GM EV1 & Telsa Model S: Looking At 20 Years Of Electric Cars. *Green Car Reports*. Retrieved from http://www.greencarreports.com/news/1087544_gm-ev1-tesla-model-s-looking-at-20-years-of-electric-cars

11 Larson, Paul D., et al. (2014). Consumer attitudes about electric cars: Pricing analysis and policy implications. *Transportation Research Part A: Policy and Practice* 69 pp. 299-314.

12 MPGe is a metric used by the US EPA to compare energy consumption rates across vehicle with different fuel types. See https://www.epa.gov/fueleconomy/electric-vehicles-learn-more-about-new-label for more information

13 Department of Energy (DOE) and Environmental Protection Agency (EPA). (2017). Fuel Economy. Retrieved from: https://www.fueleconomy.gov/feg/PowerSearch.do?action=noform&year1=2007&year2=2017&minmsrpsel=0&maxmsrpsel=0&city=0&hwy=0&comb=0&cbvtelectric=Electric&YearSel=2007-2017&make=&mclass=&vfuel=&vtype=Electric&trany=&drive=&cyl=&MpgSel=000&sortBy=Comb&Units=&url=SearchServlet&opt=new&minmsrp=0&maxmsrp=0&minmpg=&maxmpg=&rowLimit=10&pageno=1&tabView=0

However, the higher upfront cost of electric vehicles currently limits the share of these vehicles to a very small percentage of the overall market.[14] EVs are simply not yet cost effective for most consumers, even with substantial subsidies.[15] Additionally, EVs still come with several other disadvantages relative to gasoline vehicles. They have shorter ranges, take longer to refuel, and their refueling infrastructure is much less widespread and depends heavily on location. Consumers that purchase EVs tend to be wealthier and often purchase them as second or third vehicles, rather than using them as their primary vehicle.[16]

The costs and benefits of electric vehicles are not limited to the consumer, however. The question of what subsidies, if any, are appropriate is complex. To begin to address this question it is important to understand the current state of electric vehicle subsidies. The following section will explain the specific nature of these subsidies and where they are available.

Current State of EV Subsidies

Incentives for EV adoption exist at the federal level, as well as in many states and cities. Some subsidies are directed toward producers of EVs, while others are directed toward consumers. These subsidies can be direct, like tax breaks or direct payments; others are indirect, like high occupancy vehicle (HOV) lane access, or reduced cost or free access to charging stations. In this section, we discuss the overall structure of the current state of EV subsidies and other incentives in the United States.

EV Subsidies For Consumers

Direct Purchase Subsidies

Direct purchase subsidies exist at both the federal and state level. These subsidies typically take the form of either tax credits that reduce an individual's income tax burden (or increase their tax refund), or rebates, which are direct payments from the government. The federal government offers up to $7,500 as a non-refundable tax credit.[17]

The federal EV credit is offered to consumers, but can only be taken for the first 200,000 EVs produced by a given automaker. At the start of the second quarter after an automaker produces 200,000 EVs, the subsidy enters a one year "phase-out period." In the first six months of the phase-out period, any consumer who purchases a qualifying vehicle from that automaker will only receive 50 percent of the original subsidy, and in the second six months consumers will only receive 25 percent of the original subsidy. There is no limit to the number of vehicles that can receive subsidies during the phase-out period. After the phase-out period, no EVs made by that automaker will qualify for the federal purchase subsidy.[18]

Several state governments also offer direct purchase subsidies to consumers. Since the 1990s, the number of states providing purchase subsidies has fluctuated, but as of this writing there are eight.[19] Payout differs from state to state based on the specific criteria of each subsidy, but the maximum tax credits or rebates available range between $1,500

14 Larson, Paul D., et al. (2014). Consumer attitudes about electric cars: Pricing analysis and policy implications. *Transportation Research Part A: Policy and Practice* 69 pp. 299-314.

15 See, for example, Simmons, Richard A., et al. (2015). A benefit-cost assessment of new vehicle technologies and fuel economy in the US market. *Applied Energy* 157 pp. 940-952.

16 Larson, Paul D., et al. (2014). Consumer attitudes about electric cars: Pricing analysis and policy implications. *Transportation Research Part A: Policy and Practice* 69 pp. 299-314.

17 Internal Revenue Service (IRS). (2017, June 28). Qualified Vehicles Acquired after 12-31-2009. Retrieved from https://www.irs.gov/businesses/qualified-vehicles-acquired-after-12-31-2009

18 Internal Revenue Bulletin (IRS). (2009, November 30). New Qualified Plug-In Electric Drive Motor Vehicle Credit. Internal Revenue Service (IRS). Retrieved from https://www.irs.gov/irb/2009-48_IRB/ar09.html

19 California, Colorado, Connecticut, Delaware, Louisiana, Maryland, Massachusetts, and New York. See Table 2.1 in appendix

and $5,000. Subsidies in California, Colorado, Delaware, and Massachusetts provide rebates for EV purchases.[20] In Connecticut, Maryland, and New York, the subsidy payout increases with greater battery capacity or all-electric range.[21] Finally, Louisiana offers a tax credit for EVs as a percentage of the cost of the new vehicle up to a maximum limit of $1,500.[22]

Most electric vehicle sales in the United States are in California — meaning that most EV consumers are subsidized at both the state and federal level.[23] California offers a flat rebate of $2,500 based on the type of vehicle purchased, but also includes provisions to alleviate the distributional effects of older direct purchase subsidies.[24] The state does not reduce their rebate value for more expensive cars, but does offer increased rebates of up to $2,000 for qualifying individuals or families whose income falls at or below 300 percent of the poverty line, while eliminating eligibility for those various income thresholds.[25]

Four states, in addition to California, have introduced price restrictions that limit subsidies for luxury electric cars in the past two years. These restrictions hope to reduce the proportion of EV subsidies that are captured by high-income individuals. In Delaware, Maryland, and New York, available subsidies are lower for EVs that cost over $60,000.[26] Massachusetts decreases the rebate amount from $2,500 to $1,000 for Tesla vehicles specifically.[27]

Several states that previously issued subsidies have since ended their programs.[28] Some states that included electric vehicles under alternative fuel subsidies have amended them to exclude EVs, while in recent years, many EV subsidies have simply been allowed to expire. States allow these EV subsidies to expire most often because the political priorities of the state government changed in the interim to become less sympathetic to electric vehicle subsidies.[29] [30] Additionally, other subsidies were allowed to "sunset" purely because they were never intended to

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20 Center for Sustainable Energy. (2017). California Clean Vehicle Rebate Project. *CVRP Eligible Vehicles*. Retrieved from: https://cleanvehiclerebate.org/eng/eligible-vehicles.; Colorado Revised Statutes Title 39 § 39-22-5167. Tax credit for innovative motor vehicles.; Delaware Division of Energy & Climate. (2016). The Delaware Clean Vehicle Rebate Program. Retrieved from: http://dnrec.alpha.delaware.gov/energy-climate/clean-transportation/vehicle-rebates/.; Massachusetts Department of Energy Resources. (2017). MOR-EV: Eligible Vehicles List. Retrieved from:https://mor-ev.org/eligible-vehicles.

21 Connecticut Department of Energy & Environmental Protection. (2016, June 6). CHEAPR. *Electric Vehicle Incentives Available in Connecticut*.; Maryland Department of Transportation. (2017). Excise Tax Credit for Plug-in Electric Vehicles. Retrieved from: http://www.mva.maryland.gov/about-mva/info/27300/27300-71T.htm.; Charge NY. (2017, June 14). *Charge NY Drive Clean Rebate Program: Implementation Manual*.

22 Louisiana Senate Bill 243. Retrieved from: https://legiscan.com/LA/bill/SB243/2017.

23 Alliance of Automobile Manufacturers. (2017). ZEV Sales Dashboard. Retrieved from https://autoalliance.org/energy-environment/zev-sales-dashboard/

24 Center for Sustainable Energy. (2017). California Clean Vehicle Rebate Project. *CVRP Eligible Vehicles.* Retrieved from: https://cleanvehiclerebate.org/eng/eligible-vehicles.

25 Center for Sustainable Energy. (2017). California Clean Vehicle Rebate Project. *Income Eligibility*. Retrieved from: https://cleanvehiclerebate.org/eng/income-eligibility.

26 Delaware Division of Energy & Climate. (2016). The Delaware Clean Vehicle Rebate Program. Retrieved from: http://www.dnrec.delaware.gov/energy/Pages/The-Delaware-Clean-Vehicle-Rebate-Program.aspx; Maryland Department of Transportation. (2017). Excise Tax Credit for Plug-in Electric Vehicles. Retrieved from: http://www.mva.maryland.gov/about-mva/info/27300/27300-71T.htm; Charge NY. (2017, June 24). *Charge NY Drive Clean Rebate Program: Implementation Manual*.

27 Massachusetts Department of Energy Resources. (2017). MOR-EV: Eligible Vehicles List. Retrieved from: https://mor-ev.org/eligible-vehicles.

28 States with direct purchase subsidies for EVs that were ended or allowed to expire include Utah, Georgia, Hawaii, Tennessee, Rhode Island, and Oklahoma.

29 Ryan Morgan. (2017, March 1). "House Pulls Plug on Tax Credit for Energy Efficient Vehicles." Deseret News. Retreived from: http://www.deseretnews.com/article/865674575/House-pulls-plug-on-tax-credit-for-energy-efficient-vehicles.html.

30 Greg Bluestein. (2015, June 24). "Georgia's Electric Vehicle Tax Credit Ends June 30." Atlanta Journal Constitution. Retreived from: http://politics.blog.ajc.com/2015/06/24/georgias-electric-vehicle-tax-credit-ends-june-30/.

provide more than a temporary boost for the electric vehicle industry.[31 32] The estimated total cost of direct purchase subsidies for electric vehicles is below:

Estimated Total Cost of Direct Purchase Electric Vehicle Subsidies

State	Start date	End date	Approximate cost to May 2017 or expiration
California	7/2/2010	Ongoing	$456,824,706
Connecticut	5/19/2015	Ongoing	$3,741,750
Delaware	7/15/2015	Ongoing	$401,800
Massachusetts	6/1/2014	Ongoing	$5,820,000
Colorado	1/1/2010	Ongoing	$23,910,200
Louisiana	7/1/2009	Ongoing	$850,500
Maryland	7/1/2014	Ongoing	$6,025,700 to $7,233,000
New York	1/1/2017	Ongoing	$674,900 to $794,000
Rhode Island	1/1/2016	7/10/2017	$612,500
Utah	1/1/2009	12/31/2016	$2,203,360
Tennessee	9/9/2010	4/15/2016	$2,500,000
Georgia	1/1/2011	7/1/2015	$97,970,000 to $146,955,000
Hawaii	8/1/2010	5/3/2012	$2,025,000

Sources: See Appendix 1 on pages 27-29.

Charging Infrastructure Subsidies

Because EVs utilize rechargeable batteries, charging infrastructure either at home or available to the public is required to support them. Each of these options have advantages and disadvantages. Home charging stations add to the consumer's cost of purchasing and operating the vehicle while typically providing a (relatively slow) standard 120 volt electrical connection. Also known as "level one charging", this type of charging can only charge an EV at a rate of about two to five miles of additional range per hour of charging.[33] EV owners generally need to install a 240 volt, or "level two" charger in their home in order to charge an EV in a reasonable amount of time, at a rate of about 10 to 20 additional miles of range for each hour of charging, a speed necessary for EV owners that want to charge their vehicle overnight.[34] Purchase and installation costs for level two charging can cost a homeowner anywhere from $200 to $1,500.[35]

Because fast DC charging stations require more power than is available to most homeowners, these stations are generally located in public or commercial areas, and can be either privately or publicly owned. At a rate of 180 to 240

31 Clean Cities Honolulu. (2012, October). *Lessons Learned: The Early Adoption of Electric Vehicle Charging Stations from the Perspective of Oahu's Commercial Properties*. https://energy.hawaii.gov/wp-content/uploads/2011/09/lessons-learned-report-for-maui_final_10-22-12.pdf

32 Mia Yamauchi. (2017). "Updated 2017 Incentives for Electric Vehicles ad EVSE (For Tesla and More)." Plugless Power. Retrieved from: https://www.pluglesspower.com/learn/updated-2017-incentives-electric-vehicles-evse-state-federal-tax-credits-grants-loans-rebates/.

33 Alternative Fuels Data Center. (2017). US Department of Energy (DOE). Developing Infrastructure to Charge Plug-In Electric Vehicles. Retrieved from: https://www.afdc.energy.gov/fuels/electricity_infrastructure.html

34 Alternative Fuels Data Center. (2017). US Department of Energy (DOE). Developing Infrastructure to Charge Plug-In Electric Vehicles. Retrieved from: https://www.afdc.energy.gov/fuels/electricity_infrastructure.html

35 Home Advisor. (2017). How Much Does it Cost to Install an Electric Vehicle Charging Station?. http://www.homeadvisor.com/cost/garages/install-an-electric-vehicle-charging-station/

miles of range per hour of charging, fast DC chargers can charge an EV battery much quicker than level one or two chargers, though this is still slow compared to the time required to refuel a gasoline vehicle.[36]

Access to charging infrastructure is one of the most significant factors affecting widespread EV adoption.[37] While EVs can be conveniently refueled at home overnight, the ability to quickly refuel almost anywhere remains a significant advantage to owning a gasoline vehicle over an electric vehicle. Furthermore, a lack of EVs on the road may present an obstacle to private investment in EV charge stations. Overcoming this challenge to EV adoption is sometimes cited as a justification for government subsidies for charging infrastructure.[38]

From 2005 to 2016, the federal government offered a tax credit for alternative fuel infrastructure development, including residential electric charging stations, or electric vehicle supply equipment (EVSE). Over most of its existence, the tax credit's value was 30% of cost up to $1,000.[39] The subsidy expired multiple times since its passage, but was regularly renewed to grant retroactive eligibility for past purchases. At the end of 2016, the credit expired, and renewal is unlikely in the near future.

While the federal subsidy for home-charging stations no longer exists, several states offer various subsidies for the purchase, installation, or maintenance of electric vehicle charging stations. Though the majority of EVSE subsidies are only available to businesses or public organizations, seven states and Washington D.C. provide charging station tax credits or rebates to individuals. Individual subsidies range from $75 to $1,500 for individual installation of electric vehicle charging equipment. Most individual subsidies allow rebates up to the mid-hundreds and low-thousands of dollars, and almost every state includes a cap for eligibility as a percentage of the project cost, ranging from 20 to 50 percent.[40]

Exemptions and Fees

Some implicit subsidies for EVs remove restrictions or taxes that apply to most vehicle owners. Many states give EVs free access to high occupancy vehicle (HOV) lanes. Others exempt EVs from various taxes, registration fees, or inspection requirements. Certain states define and tax electricity used for electric cars at a lower rate.

Thirteen states currently allow electric vehicles to use HOV lanes without restrictions. Similarly, Arizona, Hawaii, and Nevada also provide special parking privileges to EVs. Fifteen states exempt electric vehicles from emissions tests, and nine states and D.C. offer reduced or eliminated fees and taxes.[41] Tax and inspection exemptions function similarly to HOV lane benefits in that they operate primarily to alleviate existing burdens on the state rather than to incentivize EV adoption. Because EV owners do not pay a gasoline tax intended to fund road maintenance, many states introduce additional fees for EVs to recoup that lost funding.

EV Subsidies in Cites

Most of the subsidies discussed above are also issued in some form by one or more city governments. Several of the largest cities in the US are among the most generous in their subsidies offered. While few offer direct purchase subsidies, many cities do offer HOV lane access, reduced cost or free parking, free or subsidized access to city-owned charging stations, and regulations that mandate new housing or workplaces install charging equipment. Many of the

36 Alternative Fuels Data Center. (2017). US Department of Energy (DOE). Developing Infrastructure to Charge Plug-In Electric Vehicles. Retrieved from: https://www.afdc.energy.gov/fuels/electricity_infrastructure.htmll

37 Nie, Y., et al. (January, 2016). Optimization of incentive policies for plug-in electric vehicles. *Transportation Research Part B*.; Mersky, A.C., et al. (March, 2016). Effectiveness of incentives on electric vehicle adoption in Norway. *Transportation Research Part D*.; Sierzchula, W., et al. (November, 2013). The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy*.

38 Congressional Budget Office (CBO). (September, 2012). Effects of Federal Tax Credits for the Purchase of Electric Vehicles. p. 21.

39 Alternative Fuels Data Center. (May, 2017). Department of Energy (DOE). *Energy Policy Act of 2005*. Retrieved from https://www.afdc.energy.gov/laws/epact_2005.; Natural Gas Vehicles for America. (December 2014). *Federal Incentive for Alternative Fuel Infrastructure*. Retreived from: https://www.ngvamerica.org/state-matters/federal-legislation/federal-incentive-for-alternative-fuel-infrastructure/.

40 For a full list of state subsidies for EVSEs, see Table 2.2 in the appendix.

41 For a full list of states and policies, see Table 2.3 in the appendix.

cities that offer the most subsidies are concentrated along the West Coast, including San Francisco, Los Angeles, and Portland.[42]

EV Subsidies For Producers

Federal and state governments have also subsidized the production side of electric vehicles. The American Recovery and Reinvestment Act of 2009 allocated $2 billion in grants for electric vehicle manufacturers and $400 million toward charging infrastructure.[43] At the state level, policies specifically targeting the production of EVs and EV equipment are rare. Just five states provide producer incentives for vehicle or battery manufacturers. Georgia and New Mexico offer tax credits for manufacturers, while Michigan, Montana, and South Carolina have reduced tax rates.[44]

Economic and Distributional Impacts

Government policies designed to encourage or discourage different types of economic behavior naturally change the allocation of resources in society. These changes are an important concern when evaluating whether or not a policy is desirable. When evaluating policy it is important to consider whether policies are economically efficient, or, in other words, whether the benefits of the policy exceed the cost. Another important consideration is the impact of the policy on the distribution of income. Policies that shift income away from high-income people and toward low-income people are generally referred to as progressive. In contrast, policies that shift resources toward high-income people and away from low-income individuals are referred to as regressive. Those concerned about the distributional effects of policy tend to favor progressive policies over regressive ones.

In this section, we discuss both the economic efficiency and distributional properties of EV subsidies. This discussion is based on peer-reviewed studies in the economics and transportation engineering literature.

Benefits and Costs

Advocates of increased rates of electric vehicle (EV) adoption argue that electric vehicles provide substantial benefits to society. Often, electric vehicles are credited for enabling reduced dependence on foreign energy sources,[45] reduced levels of greenhouse gas (GHG) emissions and local air pollution,[46] as well as either real or potential technological spillover benefits.[47] Because these costs and benefits do not fall on all income groups equally, understanding the total costs and benefits of electric vehicles is important when analyzing the distributional impacts of EVs.

Reducing Emissions

Reducing emissions is the primary justification for electric vehicle subsidies. The goal of reducing emissions can be especially worthwhile because, in general, pollution tends to disproportionately harm low-income people as their neighborhoods tend to be more polluted.[48] Moreover, the anticipated damages of climate change are also projected to

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42 Lutsey, N., Searle, S,. Chambliss, S,. Bandivadekar. (July, 2015). Assessment of leading electric vehicle promotion activities in United States cities. *The International Council on Clean Transportation.*

43 Department of Energy. (August, 2009). "President Obama Announces $2.4 Billion in Grants to Accelerate the Manufacturing and Deployment of the Next Generation of U.S. Batteries and Electric Vehicles." Retrieved from: https://energy.gov/articles/president-obama-announces-24-billion-grants-accelerate-manufacturing-and-deployment-next.

44 See Table 2.4 in the appendix.

45 US Department of Energy (DOE). (2017). Benefits and Considerations of Electricity as a Vehicle Fuel. Retrieved from: https://www.afdc.energy.gov/fuels/electricity_benefits.html

46 Office of Energy Efficiency & Renewable Energy. (2017). Reducing Pollution with Electric Vehicles. Retrieved from: https://energy.gov/eere/electricvehicles/reducing-pollution-electric-vehicles

47 Holland, S.P., Masur, E.T., Muller, N.Z., Yates, A.J. (December, 2016). Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors. *The American Economic Review*.

48 Banzhaf, H.S. (2011). Regulatory Impact Analysis of Environmental Justice Effects. *Journal of Land Use & Environmental Law*, 27(1), 1-30. Available at: http://www.law.fsu.edu/journals/landuse/vol27_1/banzhaf.pdf

disproportionately harm those with lower incomes.[49] Policies that reduce emissions may be justified by cost-benefit analysis or on distributional grounds. Unfortunately, it is not clear that EVs reduce emissions. In fact, depending on local factors, EVs can actually increase both local air pollution and carbon emissions.

The electricity that powers EVs is generated through many different means, many of which are not emission-free. In order to understand the difference in environmental impacts between a gasoline powered car and an electrically powered car, it's not enough to simply look at the emissions produced from the vehicles themselves. When an EV replaces a gasoline powered vehicle, the decrease in gasoline combustion must be replaced by an accompanying increase in electricity generation. While an EV powered primarily through wind, solar, hydro, nuclear, or geothermal electricity may reduce net emissions, an EV powered by coal or natural gas may increase net emissions.[50]

Because much of the electricity that powers electric vehicles is generated by fossil fuels, more electric vehicles also means more emissions from energy sources that produce harmful emissions. Thus, depending on local air quality conditions and the mix of fuels used for the local electricity grid, EVs can be a net environmental harm relative to gasoline vehicles. By examining the difference in damages between the reduction in emissions from a gasoline vehicle and the additional emissions from electric vehicles, a recent study, published in American Economic Review, found that on average, electric vehicles impose a net social cost of $1,095, though depending on where the EV is driven and recharged, this can range from costs as high as $4,964 in places like North Dakota, which has a grid that produces considerable emissions, to benefits of as high as $2,785 in places like California, which runs off a grid that is clean relative to the rest of the US.[51] The authors conclude that, on average, electric vehicle subsidies cannot be justified from their environmental benefits.

Other researchers have reached similar conclusions. For example, Coffman, Bernstein, and We find that "the environmental benefits of EVs depend critically on the electricity system from which they derive their power" and that "a regional approach to EV subsidies that can account for the emissions intensity of electricity systems may be more appropriate than the current blunt federal tax credit."[52] Archsmith, Kendall, and Rapson also conclude that, because of regional differences in what powers the grid, "there are many regions where EVs provide a decisive benefit and others where EVs are significantly worse."[53] Similarly, Zivin, Kotchen, and Mansur find that EVs generate fewer emissions in Texas and the western United States, but not in the upper Midwest when charged at night, a time of day when the sources of electricity are more likely to produce emissions.[54]

The EV credit is also a highly inefficient method to reduce carbon emissions. The CBO has estimated that the EV credit costs the federal government anywhere from $230 to $4,400 for every ton of carbon dioxide emissions that the subsidy reduces.[55] This cost vastly exceeds the federal government's own estimates of the social cost of carbon, which range from $12 to $123 in 2020.[56] Even the government's highest estimate of unexpectedly high-impact climate change in 2050 of $212 per ton of carbon is lower than the lowest estimate of the cost of the EV credit per ton of carbon reduced.

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49 Hsiang, S., et al. (2017, June 30). Estimating economic damage from climate change in the United States. *Science*. Retrieved from http://science.sciencemag.org/content/356/6345/1362/tab-pdf

50 Holland, S.P., Masur, E.T., Muller, N.Z., Yates, A.J. (December, 2016). Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors. *The American Economic Review*.

51 Holland, S.P., Masur, E.T., Muller, N.Z., Yates, A.J. (December, 2016). Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors. *The American Economic Review*.

52 Coffman, M., Bernstein, P., Wee, S. (2017) Integrating electric vehicles and residential solar PV. *Transport Policy (53)* pp. 30-38.

53 Archsmith, J., Kendall, A., Rapson. D. (2015) From cradle to junkyard: assessing the life cycle greenhouse gas benefits of electric vehicles. *Research in Transportation Economics* (52). pp. 72-90.

54 Zivin, J.S., Graff, M., Kotchen, J., Mansur, E.T. (2014) Spatial and temporal heterogeneity of marginal emissions: Implications for electric cars and other electricity-shifting policies. *Journal of Economic Behavior & Organization (107)*. pp. 248-268.

55 Congressional Budget Office (CBO). (September, 2012). Effects of Federal Tax Credits for the Purchase of Electric Vehicles.

56 Environmental Protection Agency (EPA). (2016). EPA Fact Sheet: Social Cost of Carbon. Retrieved from: https://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf

Incentivizing EV Purchases

In areas where EVs do improve environmental outcomes, subsidies only help with this if they incentivize more EV purchases than there would have been without the subsidy. If these vehicles would have been purchased regardless of the subsidy, then the subsidy is simply a direct wealth transfer. It appears that most electric vehicle purchases would have been made without the subsidy. In 2012 the Congressional Budget Office estimated that the federal tax credit was responsible for incentivizing only about 30 percent of new EV sales, while 70 percent would have occurred without the federal subsidy.[57] Later empirical findings show that at most 40% of EV purchases could be attributed to subsidies from 2011 to 2013.[58]

Because new electric vehicles are expensive, those with the high income necessary to purchase an EV may be unlikely to consider the presence of a subsidy as a deciding factor. There is also evidence from a stated choice experiment to suggest that those who already have low carbon footprints when using transportation, specifically those who drive less than 15,000 km (or a little more than 9,000 miles) a year, use public transportation, and ride bicycles, may be much more likely to take advantage of EV subsidies than those who drive gasoline cars a significant amount.[59] This could possibly be because low-carbon methods of transportation, including biking and public transit may already have many of the inconveniences associated with electric vehicles, including short ranges and the potential for wait times, and electric vehicles are likely more convenient than biking or public transportation. Those who rely on their gasoline vehicle as their sole means of transportation and use it for long trips may find the inconveniences of electric vehicles too great despite the subsidies offered.[60] If this is the case, then EV subsidies may actually make pollution problems worse by incentivizing those with low carbon footprints to increase their use of carbon producing transportation by shifting from biking and public transportation, without incentivizing the replacement of gasoline vehicles with electric vehicles.

Innovation Spillover Effects

Subsidies also appear unlikely to have significant technological spillover effects. In this context, spillover effects happen when the knowledge created by one EV automaker "spills over" to other EV automakers.[61] In a more general sense, the main justification for public funding for research and development is that the benefits of research may not be fully captured by those who bear the costs. New innovations can have widely spread benefits to society as a whole, which can result in underinvestment from private markets. Technological breakthroughs benefit those who had no hand in developing them, which means that the incentive to develop the technology is not as high as the social benefits of the technology. If this is true, then research is underfunded relative to its social value.[62]

Governments have several ways of encouraging research and development, including directly funding research, raising taxes on undesirable technologies, and subsidizing desirable technology adoption.[63] When compared to direct research and development support, direct purchase subsidies are a less effective tool for encouraging innovation.[64] Generally subsidies are intended to assist an industry in the initial stages of development, when costs are high, by stimulating demand until costs are brought down to a sustainable level. When subsidies do not substantially stimulate demand they run the risk of merely serving as direct wealth transfers, and the case of EV subsidies the main beneficiaries are generally high-income people.

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57 Congressional Budget Office (CBO). (September, 2012). Effects of Federal Tax Credits for the Purchase of Electric Vehicles.

58 Li, Shanjun, Lang Tong, Jianwei Xing, Yiyi Zhou. (2017). The Market for Electric Vehicles: Indirect Network Effects and Policy Design. *Journal of the Association of Environmental and Resource Economists*

59 Rudolph, C. (2016). How may incentives for electric cars affect purchase decisions?. *Transport Policy*.

60 Rudolph, C. (2016). How may incentives for electric cars affect purchase decisions?. *Transport Policy.*

61 Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics*.

62 Martin, S., Scott, J.T. (2000). The nature of innovation market failure and the design of public support for private innovation. *Research Policy*.

63 Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics*. pp 170-172

64 Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics*. pp.172

For decades, federal and state governments have funded research in an attempt to improve EV technology. Encouraging innovation may be a worthwhile endeavor, but not all methods of doing so are equally effective. The process of innovation can be broken down into two steps. Researchers first develop new technical ideas, followed by commercial users adopting the new technology and replacing the old technology.[65] Subsidies for purchasing technology that reduces pollution is one of the least effective ways of reducing pollution because it does not discourage consumers from continuing to use polluting technology.[66] Research suggests that policies directed at specific technologies are less effective than technology-neutral policies such as a carbon tax.[67] Governments usually cannot predict which technology will be the most cost effective means of reducing emissions before that technology is developed, so too much early support of a particular technology can "lock-in" a particular technology, when a superior technology may have achieved widespread adoption instead.[68]

Direct research subsidies are also problematic. Additional funding may not be able to significantly increase the number of scientists and engineers with sufficient skills. Developing scientific or engineering skills is a long process with many natural barriers. If the supply of scientists and engineers is too small, and does not significantly respond to additional research funding, then much of the additional funding may simply be captured in the form of higher salaries without a corresponding increase in innovation.[69] Better policies should encourage the creation of market conditions where innovation can more easily happen. Ideally, innovation policies will start with an end goal specified, reducing emissions for example, but with no preference to the technological means taken to get there.[70]

Regressive Effects

While it is unclear if electric vehicle subsidies provide environmental benefits on net, it is clear that the subsidies themselves are highly regressive.[71] Direct subsidies for new vehicles are generally claimed by those with higher incomes for a number of reasons. First, because wealthy people are more likely to purchase new vehicles, subsidies for new car purchases (EV or not) will tend to benefit the wealthy. Additionally, electric vehicles tend to have lower ranges than gasoline vehicles, making them less attractive as a household's first vehicle. Households that purchase electric vehicles are therefore more likely to be able to afford several vehicles, rather than just one. Finally, because many electric vehicle are expensive compared to gasoline vehicles, they tend to be purchased by wealthier individuals. These factors have the combined effect of making policies that subsidize the purchase of electric vehicles particularly regressive, even when compared with other clean energy policies in the United States.[72]

The primary EV purchase subsidy in the United States is known as the Qualified Plug-in Electric Drive Motor Vehicle Credit. This federal subsidy provides a substantial tax credit for new vehicle purchases. The credit applies to new vehicles only, and ranges from $2,500 to $7,500 depending on the size of the purchased vehicle's battery. Both plug-in hybrids and fully electric vehicles qualify for this credit. Fully electric vehicles almost always have the battery size that allows them to receive the full $7,500, while plug-in hybrids sometimes only qualify for a smaller subsidy.[73]

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65 Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics*.

66 Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics*.

67 Fox, J., Axsen, J., Jaccard. M. (2017) Picking Winners: Modelling the Costs of Technology-specific Climate Policy in the US Passenger Vehicle Sector. *Ecological Economics* (137) pp. 133-147.

68 Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics*.

69 Goolsbee, A. (May, 1998). Does Government R&D Policy Mainly Benefit Scientists and Engineers? *The American Economic Review*.

70 Martin Scott; Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics*.

71 West, S.E. (March, 2004). Distributional Effects of Alternative Vehicle Pollution Control Policies. *Journal of Public Economics*.

72 Borenstein, S., Davis, L.W. (July, 2015). The Distributional Effects of U.S. Clean Energy Tax Credits. *National Bureau of Economic Research Working Paper Series*.

73 Internal Revenue Service (IRS). (2017, June 28). Qualified Vehicles Acquired after 12-31-2009. Retrieved from https://www.irs.gov/businesses/qualified-vehicles-acquired-after-12-31-2009

This federal subsidy is a non-refundable tax credit, which means that it reduces a person's tax liability but does not add to their refund if their liability is zero.[74] This has the effect of exacerbating the regressive effects of the subsidy because only those with enough income to pay federal income taxes can benefit from the subsidy. Moreover, only those with an income high enough to owe $7,500 in federal tax liability can receive the full subsidy. In other words, individuals that are able to take full advantage of the subsidy are those who are the least likely to need the subsidy in order to afford an expensive electric vehicle in the first place.

Researchers for the National Bureau of Economic Research have found evidence that the EV credit is exceptionally regressive, substantially more so than the three other clean energy subsidies they studied. These include the Nonbusiness Energy Property Credit, a subsidy that pays for homeowners to make their homes more energy efficient, the Residential Energy Efficient Property Credit, which subsidizes home solar panels, solar water heaters, and fuel cells, and the Alternative Motor Vehicle Credit, which subsidizes hybrids, hydrogen, natural gas, and other non-gasoline vehicles. Data from the IRS show that for the Qualified Plug-in Electric Drive Motor Vehicle Credit the vast majority of the subsidy goes to the highest income earners, with the top 20% of earners receiving 90% of the credit.[75]

Not only do EV subsidies overwhelmingly flow towards those at the upper end of the income distribution, the environmental benefits of electric vehicles are also mostly captured by those with higher than average incomes. The authors of an NBER working paper that examines the income of areas where pollution is produced and abated when electric vehicles replace gasoline vehicles find that "Census block groups with median income greater than about $65,000 receive positive environmental benefits from electric vehicle adoption whereas block groups with income less than this threshold receive negative environmental benefits."[76] The harmful effects of emissions from gasoline vehicles are generally concentrated near the areas where they are driven, while the harmful effects of electricity generation emissions are more likely to affect those who live near power plants. If people who live in wealthy neighborhoods are more likely to purchase electric vehicles, and if low-income people are more likely to live near power plants where property values are lower, then the benefits of an electric vehicle replacing a gasoline vehicle will be mostly received by the driver's wealthy neighbors. However, the harms will be received by low-income people who live near the power generation facilities that must produce extra power for the electric vehicle.

By 2012, $346 million had been spent on the federal EV credit, but this is far from the potential cost. The Congressional Budget Office (CBO) estimates that the amount of subsidy given to EV consumers could total up to $1.5 billion in lost tax revenue for each qualifying automaker, and potentially more if many EVs are sold during the phaseout period.[77] If the number of current automakers remains constant, we estimate that the subsidy could end up costing anywhere from $15 to $20 billion over the life of the program, with the vast majority of those benefits received by the wealthy.

We estimate this number by assuming that all automakers who are currently producing electric vehicles will continue to do so. Depending on which vehicles they purchase, not all consumers receive the full $7,500, so we use the lowest and highest subsidies offered to predict a possible range. Using IRS figures for the subsidy offered for each vehicle, we assume that if a subsidy is claimed for each automaker's 200,000 vehicles, the costs could eventually reach $15 to $20 billion.[78] This is likely a conservative estimate. While we do not account for consumers that purchase vehicles but are not qualified to receive the subsidy, which would lower our estimate, we also do not include the phaseout period, which would substantially increase our estimate.

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74 Borenstein, S., Davis, L.W. (July, 2015). The Distributional Effects of U.S. Clean Energy Tax Credits. *National Bureau of Economic Research Working Paper Series*. pp. 22

75 Borenstein, S., Davis, L.W. (July, 2015). The Distributional Effects of U.S. Clean Energy Tax Credits. *National Bureau of Economic Research Working Paper Series*. pp. 1

76 Holland, S.P., Mansur, E.T., Muller, N.Z., Yates, A.J. (November, 2016). Distributional Effects of Air Pollution from Electric Vehicle Adoption. The National Bureau of Economic Research. Working Paper. pp. 2. Retrieved from http://www.nber.org/papers/w22862

77 Congressional Budget Office (CBO). (September, 2012). Effects of Federal Tax Credits for the Purchase of Electric Vehicles. pp. 3. Retrieved: https://www.cbo.gov/sites/default/files/112th-congress-2011-2012/reports/09-20-12-electricvehicles0.pdf

78 Internal Revenue Service (IRS). (2017, June 28). Qualified Vehicles Acquired after 12-31-2009. Retrieved from https://www.irs.gov/businesses/qualified-vehicles-acquired-after-12-31-2009

Even if more electric vehicle ownership is a worthwhile policy goal, direct subsidies may not be the most effective way to achieve this goal. Access to charging infrastructure is a concern of adopters of electric vehicles.[79] Subsidies that provide additional charging infrastructure tend to be more successful at encouraging EV adoption than direct EV subsidies.[80] This may be because of an indirect network effect between electric vehicles and charging stations. As electric vehicles become more common, there is a greater incentive for investors to build charging stations, and as charging stations become more common, the costs to consumers of limited EV ranges decreases, which encourages more EV purchases. These effects can result in a "feedback loop" where more electric vehicles stimulate more charge station investment which in turn stimulate more electric vehicle purchases.[81] Because the effect of charge stations on electric vehicle production is greater than the reverse effect, subsidizing charge stations is significantly more effective than EV purchase subsidies.[82]

Charging infrastructure subsidies may also have more equitable distributional impacts. Because many direct EV subsidies expire over time and only apply to new vehicle purchases, they are generally only afforded to those with higher incomes. Charging infrastructure, however, remains in place long after the initial subsidy. As new electric cars decline in price, and as current electric cars enter the used car market, people with lower incomes can also take advantage of charging infrastructure, implying that these types of subsidies may be less regressive than direct purchase subsidies.

Conclusion

While electric vehicles may have long-term potential to reduce pollution and carbon emissions, the high cost and extremely regressive nature of EV subsidies, as well as the current lack of clear environmental benefits from electric vehicles, indicate that these subsidies come at an enormous cost relative to the benefits they generate. Rather than effectively advancing the goals of reducing carbon emissions or encouraging innovation, EV subsidies mainly function as a mechanism to transfer resources to the wealthy.

A subsidy can be economically justified if the spillover benefits exceed the opportunity cost of the money spent. Any positive effects, however well-intentioned, must be carefully weighed against any negative consequences as well. One of the negative consequences of any government spending program is that the funds spent on a particular program cannot be used elsewhere for other, potentially more socially beneficial purposes.

If a subsidy provides any benefits at all, regardless of costs, this is not enough to justify it as the costs may exceed the benefits. Even if the benefits of a subsidy are greater than its costs, this is also not enough to justify it, because the resources used may provide even greater benefits elsewhere. In other words, in order to justify a subsidy, it is not enough to show that the benefit of the subsidy is positive, or even that the benefit of the subsidy minus the cost of the subsidy is positive. It is also necessary to show that the net benefits of a subsidy exceeds the net benefits of alternative uses of the funds.

Our review of the literature concludes that electric vehicle subsidies do not meet this standard and cannot be justified by either economic efficiency or economic fairness considerations.[83] EV subsidies distort economic incentives causing welfare losses, exacerbate economic inequality, and do not show robustly positive environmental benefits. Given these considerations, we recommend eliminating the subsidies for these vehicles.

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79 Stafford, E. R. (June, 2017). Bridging the Chasm: An Early Adopter's Perspectives on How Electric Vehicles Can Go Mainstream. *Sustainability: The Journal of Record*. pp. 166. Retrieved from: http://online.liebertpub.com/doi/10.1089/sus.2017.29102.ers

80 Nie, Y., et al. (January, 2016). Optimization of incentive policies for plug-in electric vehicles. *Transportation Research Part B*. pp. 120.

81 Li, Shanjun, Lang Tong, Jianwei Xing, Yiyi Zhou. (2017). The Market for Electric Vehicles: Indirect Network Effects and Policy Design. *Journal of the Association of Environmental and Resource Economists*

82 Ibid.

83 See, for example, Irvine, I. (2017). The Marginal Social Value of Electric Vehicle Subsidies — Preliminary Evidence. *Economics Bulletin* (37.1) pp. A13. ; or Dimitropoulos, A., et al. (2016) Not fully charged: Welfare effects of tax incentives for employer-provided electric cars. *Journal of Environmental Economics and Management (78)* pp. 1-19.;

Key Findings

- Subsidies for electric vehicles are widespread, varied, and are funded by federal, state, and city governments. They include subsidies for consumer purchases of EVs, subsidies for producers of EVs, subsidies for EV infrastructure, and other various side benefits to EV owners.
- The total cost of EV subsidies is substantial. The federal subsidy could end up costing as much as $15 to $20 billion, while the cost of state subsidies could be as high as $400 million to almost $500 million.
- Electric vehicles can provide environmental benefits if the electricity they use comes from a clean grid. Unfortunately, these benefits are relatively small, and wealthy neighborhoods are more likely to receive them. More frequently, electric vehicles can cause environmental damages when the gasoline they displace is replaced by dirtier fuels like coal.
- Electric vehicles can reduce carbon emissions, but the cost of reducing a ton of carbon through EV subsidies is vastly greater than the EPA's estimates of how much damage a ton of carbon causes.
- Innovation spillovers could result from electric vehicle research and development, but direct consumer subsidies are an expensive and ineffective method for generating innovation.
- Electric vehicle subsidies are highly regressive, even when compared with other clean energy subsidies. The benefits of this subsidy are concentrated among those who have high incomes, while the costs are dispersed among all taxpayers.

Appendix

Sources for Table 1

NOTE: All figures for vehicles registered were retrieved from the ZEV Sales Dashboard, found here: https://autoalliance.org/energy-environment/zev-sales-dashboard/

- **California:** Figure from the California Clean Vehicle Rebate statistics page. Retrieved from: https://cleanvehiclerebate.org/eng/rebate-statistics.
- **Colorado:** This figure is based on two subsidies. The first had an average payout of $3,900 and was active from January 1, 2011 (the beginning of our available vehicle registration data) and ended December 31, 2016. During this period 4,718 battery-only electric vehicles (BEVs) were registered in the state and assumed to have used the incentive. The cost of this program was calculated by multiplying the number of registered BEVs by the average value of the subsidy for a value of $18,400,200. The second subsidy became active on January 1, 2017, and is still available, offering a flat rebate of $5,000 for BEV purchase. From January 2017 to May 2017 (the latest date of registration data) 1,102 BEVs were registered in the state. The cost of this program was calculated by multiplying the number of registered BEVs by the value of the subsidy for a value of $5,510,000. The estimated costs of the two subsidies were added to one another for a final value of $23,910,200. The value of the subsidies was retrieved from: Colorado Revised Statutes Title 39 § 39-22-5167. Tax credit for innovative motor vehicles.
- **Connecticut:** Figure from the Connecticut CHEAPR Program statistics page. Retrieved from: http://www.ct.gov/deep/cwp/view.asp?a=2684&q=565018&deepNav_GID=2183
- **Delaware:** The estimated cost of EV subsidies in Delaware is based on two programs. The first offered $2,200 for BEV purchase and was active from July 15, 2015 to October 31, 2016. During this period 84 BEVs were registered in the state. The cost of the program was estimated by multiplying the number of registered BEVs by the value of the subsidy for a value of $184,800. The second subsidy became active on November 1, 2016 and is still available for a rebate of $3,500 for BEV purchase. From November 2016 to May 2017, 62 BEVs were registered in Delaware. The cost of the subsidy was estimated by multiplying the number of registered BEVs by the value of the subsidy for a value of $217,000. The estimated costs of the two subsidies were added to one another for a final cost of $401,800. The value of the subsidy pre-November 2016 was retrieved from: Delaware Division of Energy & Climate. (2016). The Delaware Clean Transportation Incentive Program. Retrieved from: http://www.dnrec.delaware.gov/energy/Pages/Clean-Transportation-July2015-October2016.aspx. The value of the subsidy November 2016 onward was retrieved from: Delaware Division of Energy & Climate. (2016). The Delaware Clean Vehicle Rebate Program. Retrieved from: http://dnrec.alpha.delaware.gov/energy-climate/clean-transportation/vehicle-rebates/.
- **Georgia:** From January 2011 to June 2015, there were two overlapping subsidies for zero emissions vehicles and alternative fuel vehicles. In our low-cost scenario, consumers only applied for the zero-emission vehicle tax credit for a value of $5,000. In our high-cost scenario, consumers applied for both the AFV and ZEV credits for a value of $2,500 and $5,000, respectively. To estimate the cost of the subsidies, we multiplied the high- and low-cost credits by 19,594 — the number of BEVs sold from January 2011 to June 2015. The value of the subsidies was retrieved from: Hiroko Tabuchi. (2017, March 11). "Behind the Quiet State-by-State Fight Over Electric Vehicles." *The New York Times*. Retrieved from: https://www.nytimes.com/2017/03/11/business/energy-environment/electric-cars-hybrid-tax-credits.html?mcubz=3.
- **Hawaii:** 450 BEVs were sold in Hawaii during the availability of a subsidy that ran from August 1, 2010 to May 3, 2012. This number was multiplied by the value of the subsidy ($4,500). Information retrieved from: http://evtc.fsec.ucf.edu/publications/documents/HNEI-05-15.pdf
- **Loisiana:** The estimated cost of EV subsidies in Louisiana is based on a program that was amended in 2014. The pre-amendment subsidy offered $3,000 for BEV purchase and was active from January 2011 (the beginning of our available vehicle registration data) to December 2014. During this period 178 BEVs were registered in the state. The cost of the program during this period was estimated by multiplying the number

of registered BEVs by the value of the subsidy, for a value of $534,000. The program was amended on January 2015 to decrease the subsidy to $1,500 per vehicle. As of the date of latest vehicle registration data (May 2017), this subsidy was still available for $1,500. During this period, 211 BEVs were registered in Louisiana. The cost of the subsidy was estimated by multiplying the number of registered BEVs by the value of the subsidy for a value of $316,500. The total cost of the subsidy was estimated by adding the two values together for a final cost of $850,500. The value of the subsidies was retrieved from: Louisiana Senate Bill 243. Retrieved from: https://legiscan.com/LA/bill/SB243/2017.

- **Massachusetts:** Figure from the MOR-EV Program Statistics page. Retrieved from: https://mor-ev.org/program-statistics
- **Maryland:** The estimated cost of EV subsidies in Maryland was calculated by multiplying the number of BEVs sold in the state (2,411) during the active subsidy period (July 1, 2014 to May 31, 2017) by the minimum ($2,500) and maximum ($3,000) values of the subsidy for a final estimated cost of $6,025,700 to $7,233,000. The value of the subsidies was retrieved from: Maryland Department of Transportation. (2017). Excise Tax Credit for Plug-in Electric Vehicles. Retrieved from: http://www.mva.maryland.gov/about-mva/info/27300/27300-71T.htm.
- **New York:** The estimated cost of EV subsidies in New York was calculated by multiplying the number of BEVs sold in the state (397) during the active subsidy period (April 1, 2014 to May 31, 2017) by a the minimum ($1,700) and maximum ($2,000) values of the subsidy for a final estimated cost of $674,900 to $794,000. The value of the subsidy was retrieved from: Charge NY. (2017, June 14). *Charge NY Drive Clean Rebate Program: Implementation Manual*.
- **Rhode Island:** The estimated cost of EV subsidies in Rhode Island was calculated by multiplying the number of BEVs sold in the state (245) during the active subsidy period (January 1, 2016 to June 31, 2017) by a the value of the subsidy ($2,500) for a final estimated cost of $612,500. The value of the subsidy was retrieved from: Driving Rhode Island to Vehicle Electrification. (2017). "DRIVE - Eligible Vehicle List." State of Rhode Island. Retrieved from: http://www.drive.ri.gov/apply/eligible-vehicle-list.php.
- **Tennessee:** This program had a total budget of $2,500,000 that was exhausted in April 2015. Information retrieved from: http://insideevs.com/tennessee-brings-back-plug-electric-car-rebate-program/.
- **Utah:** The estimated cost of EV subsidies in Utah was based on two programs. The first subsidy offered $605 for BEV purchase and was active from January 2011 (the beginning of our available vehicle registration data) to December 31, 2014. During this period 932 BEVs were registered in the state. The cost of the program during this period was estimated by multiplying the number of registered BEVs by the value of the subsidy, for a value of $563,860. The second program ran from January 1, 2015 to December 31, 2016, and increased the subsidy value to $1,500. During this period, 1,093 BEVs were registered in Utah. The cost of the subsidy was estimated by multiplying the number of registered BEVs by the value of the subsidy for a value of $1,639,500. The estimated costs of the two subsidies were added to one another for a total cost of $2,203,360. Information retrieved from: https://deq.utah.gov/ProgramsServices/programs/air/cleanfuels/taxcredits/taxcreditsintro.htm.

Table 2.1 - Direct purchase subsidies for individuals

State	Subsidy Type	Description	Start	Expire
California	Rebate - Electric vehicle	This rebate offers up to $2500 for a new EV purchase. Individual applicants under a certain income threshold are eligible to receive an additional $2000. Rebate is restricted for those above a certain income threshold.	7/2/2010	N/A
Connecticut	Rebate - Electric vehicle	Rebate offers up to $3000 for a new EV purchase.	5/19/2015	N/A
Delaware	Rebate - Electric vehicle	Rebate offers up to $3500 for a new EV purchase. The rebate is reduced to $1000 if the vehicle's MSRP is above $60000.	7/15/2015	5/30/2018
Massachusetts	Rebate - Electric vehicle	Rebate offers up to $2500 for a new EV purchase. The rebate is reduced for vehicles priced at over $60000.	6/1/2014	N/A
Colorado	Tax credit - Electric vehicle	Offers a $5000 credit for purchase of a new EV, and $2500 for lease. These values decrease in 2020 and 2021.	1/1/2017	1/1/2022
Louisiana	Tax credit - Electric vehicle	This credit offers 7.2% of vehicle cost up to $1500.	7/1/2009	1/1/2018
Maryland	Tax credit - Electric vehicle	Offers a credit of up to $3000 for a new EV purchase ($100 per kWh battery capacity). Reduced credit for vehicles priced at over $60000.	7/1/2017	6/30/2020
New York	Tax credit - Electric vehicle	Offers up to $2000 for a new EV purchase. Reduced credit for vehicles priced at over $60000.	1/1/2017	N/A

California: Center for Sustainable Energy. (2017). California Clean Vehicle Rebate Project. *CVRP Eligible Vehicles*. Retrieved from: https://cleanvehiclerebate.org/eng/eligible-vehicles.

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Maryland: Maryland Department of Transportation. (2017). Excise Tax Credit for Plug-in Electric Vehicles. Retrieved from: http://www.mva.maryland.gov/about-mva/info/27300/27300-71T.htm.

New York: Charge NY. (2017, June 14). *Charge NY Drive Clean Rebate Program: Implementation Manual.*

Table 2.2 - Direct purchase subsidies for charging equipment for individuals

State	Subsidy Type	Description	Eligibility	Expire
Delaware	Rebate - EVSE	Rebate offers 50% of the cost of an EVSE up to $500 for residential use. Offers 75% of cost up to $2500 for commercial use. Offers 75% of cost up to $5000 for workplace use.	Residential, Commercial, Workplace	5/30/2018
Maryland	Rebate - EVSE	Rebate offers $700 for individual purchase of EVSE. Offers $4000 for government or business use. Offers $5000 for retail service.	Residential, Commercial, Workplace, Government	6/30/2020
Arizona	Tax credit - EVSE	Offers credit of up to $75 for residential EVSE installation.	Residential	N/A
District of Columbia	Tax credit - EVSE	Credit offers 50% of the cost of alternative fueling property up to $1000 for residential use. Commercial use is eligible for $10000.	Residential, Commercial	12/31/2026
Georgia	Tax credit - EVSE	Credit offers 10% of the cost of publicly available EVSE up to $2500.	Commercial	N/A
Missouri	Tax credit - EVSE	Credit offers 20% of cost of EVSE up to $1500 for individual use. Businesses eligible for $20000.	Residential, Commercial, Workplace	1/1/2018
New York	Tax credit - EVSE	Credit offers 50% of alternative fuel infrastructure costs up to $5000.	Residential, Commercial, Workplace	12/31/2022
Oregon	Tax credit - EVSE	Credit offers up to 35% of fueling infrastructure for businesses.	Workplace, Commercial	12/31/2018
Oregon	Tax credit - EVSE	Credit offers 25% to 50% of infrastructure costs up to $750 for residents.	Residential	12/31/2017
Oklahoma	Tax credit - EVSE	Credit offers up to 75% of the cost of fueling infrastructure for commercial use.	Commercial	1/1/2020
Colorado	Grant - EVSE	Grant offers 80% of the cost of EVSE installation up to $3260 for Level 2 or $13,000 for DC fast charging. If charging equipment has multiple ports, offer increases to $6260 and $16,000, respectively.	Commercial, Workplace, Government	N/A
Connecticut	Grant - EVSE	Grant offers "50% of project costs (up to $2,000 per unit and $4,000 per site) to 100% of project costs (up to $10,000 per site), depending on how well the project matches program criteria. For EVSE that is available to the public 24 hours a day, 7 days a week, and located in a major downtown area or other central destination currently underserved by EVSE, DEEP will provide up to $5,000 per unit or up to $10,000 per site."	Commercial, Government	N/A
Maryland	Grant - EVSE	Private businesses are eligible to receive $35000 to $500000 grants as long as applicant pays for 50% of project cost.	Commercial, Workplace	N/A
Massachusetts	Grant - EVSE	Grant offers up to $13500 for EVSE purchase	Government	N/A
Massachusetts	Grant - EVSE	Grant offers 50% of cost of Level 1 or 2 EVSE for workplaces, up to $25000.	Workplaces	N/A

State	Subsidy Type	Description	Eligibility	Expire
New Jersey	Grant - EVSE	Grant offers up to $250 for Level 1 and $5000 for Level 2 installation in a workplace.	Workplace	N/A
Utah	Grant - EVSE	Grant covers the cost of fueling equipment for public or private businesses and government organizations.	Workplace, Government	N/A
Washington	Grant - EVSE	Utilities can apply for a partial return for the cost of charging station equipment.	Commercial	N/A

All policies were accessed from:

Alternative Fuels Data Center. (2017). State Laws and Incentives database. Department of Energy (DOE). Retrieved from: https://www.afdc.energy.gov/laws/state

Table 2.3 - Exemptions for electric vehicles

State	Exemption Type	Description
Arizona	Emissions inspection	Electric vehicles are exempt from emissions inspections. Exemption expires after the first registration year.
Arizona	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Arizona	Parking restrictions	Alternative fuel vehicles can park in parking areas designated for carpool operators.
California	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Colorado	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Colorado	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Colorado	Tax	Low-emissions vehicles are exempt from sales tax.
Connecticut	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Connecticut	Tax	Reduced registration fee for electric vehicles.
District of Columbia	Tax	Reduced registration fee for electric vehicles.
District of Columbia	Tax	Excise tax exemption for electric vehicles.
Florida	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Georgia	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Hawaii	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Hawaii	Parking restrictions	Electric vehicles are exempt from some state and county parking fees.
Idaho	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Illinois	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Illinois	Tax	Reduced registration fee for electric vehicles.
Maryland	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Massachusetts	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Michigan	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Missouri	Emissions inspection	Electric vehicles are exempt from emissions inspections
Nevada	Emissions inspection	Electric vehicles are exempt from emissions inspections
Nevada	HOV lane	Electric vehicles can drive in HOV lanes
Nevada	Parking restrictions	Alternative fuel vehicles may park in public metered parking areas without paying a fee.
New Jersey	Tax	Zero emission vehicles are exempt from sales and use tax.

State	Exemption Type	Description
New Jersey	Tax	Toll discount for EVs during off-peak hours on all Port Authority of New York and New Jersey crossings.
New York	Emissions inspection	Electric vehicles are exempt from emissions inspections.
New York	HOV lane	EV drivers can use Long Island Expressway HOV unrestricted.
New York	Tax	Toll discount for EVs during off-peak hours on all Port Authority of New York and New Jersey crossings.
North Carolina	Emissions inspection	Electric vehicles are exempt from emissions inspections.
North Carolina	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
North Carolina	Tax	Sale, use, storage, and consumption of alternative fuels is exempt from sales and use tax.
Ohio	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Rhode Island	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Tennessee	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Utah	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Utah	Tax	Electricity used to power electric vehicles is exempt from state fuel taxes. Instead, electricity is subject to three-nineteenths of the existing fuel tax.
Virginia	Emissions inspection	Electric vehicles are exempt from emissions inspections.
Virginia	HOV lane	Electric vehicles can drive in the HOV lane without restriction.
Washington	Emissions exemption	Electric vehicles are exempt from emissions inspections.
Washington	Tax	New alternative fuel vehicles are exempt from sales and use tax. Eligible vehicles must be priced at $42500 or less.

All policies were accessed from:

Alternative Fuels Data Center. (2017). State Laws and Incentives database. Department of Energy (DOE). Retrieved from: https://www.afdc.energy.gov/laws/state

Table 2.4 - Subsidies for EV and EV component producers

State	Subsidy	Description
Georgia	Producer incentive	Businesses that manufacture products for use in batteries or electric vehicles are eligible for an annual tax credit based on employee growth relative to regional employment and income levels.
Michigan	Producer incentive	Tax exemption is available for property used for industrial "high technology," including EVs and components.
Montana	Producer incentive	Vehicle manufacturers pay reduced property tax of 3% market value. Manufacturers may also qualify for a tax abatement of up to 15 years.
New Mexico	Producer incentive	Electric vehicle manufacturers meeting certain job qualifications are eligible for a tax credit of up to 5% of qualifying expenditures.
South Carolina	Producer incentive	The taxable value of machinery or equipment purchased for renewable energy manufacturing facilities may be reduced by 20% of original cost.

All policies were accessed from:

Alternative Fuels Data Center. (2017). State Laws and Incentives database. Department of Energy (DOE). Retrieved from: https://www.afdc.energy.gov/laws/state