



EVALUATION OF STATE-LEVEL U.S. ELECTRIC VEHICLE INCENTIVES

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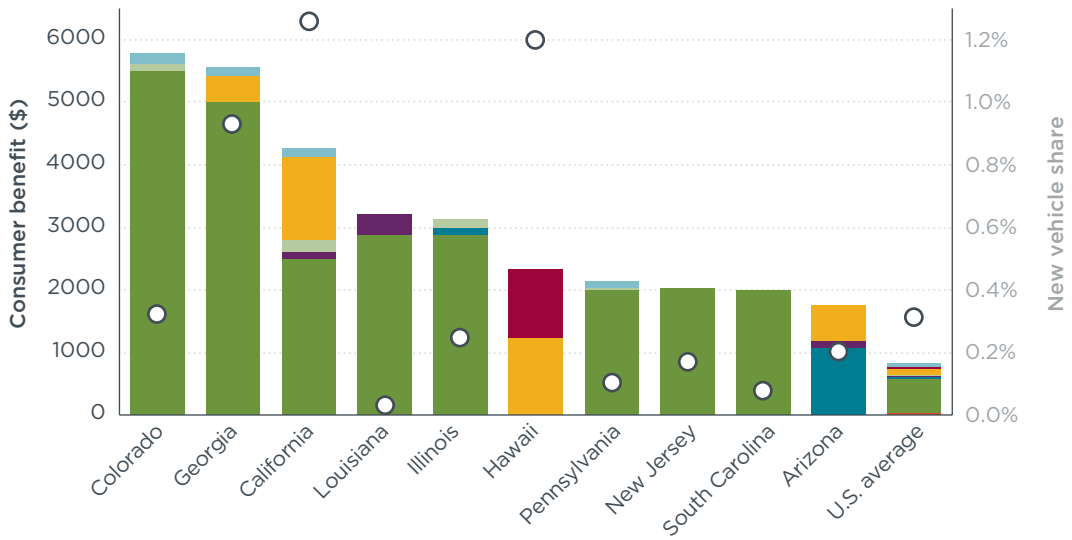
EXECUTIVE SUMMARY

Governments around the world have established electric vehicle incentives with the aim of reducing petroleum use, greenhouse gas (GHG) emissions, and local air pollutant emissions. In 2013, nearly 100,000 plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) were sold in the U.S., but that number falls well short of national policy targets. In addition to federal efforts to promote electric vehicles, state and local governments have begun offering electric vehicle incentives in recent years. This upwelling of support for electric vehicles raises several questions. One basic question is the total value of state-level actions terms of per-vehicle consumer benefits that could tip the scales toward higher electric vehicle sales. Further, are the various state electric-vehicle incentives beginning to significantly influence electric vehicle adoption rates? In this early stage of electric vehicle market development, governments could benefit from an improved understanding of best-practice policies emerging to cost-effectively spur electric vehicle sales.

This paper seeks to answer these questions by comparing the total monetary benefit available to consumers through U.S. state incentives to electric vehicle sales in 2013. In order to quantitatively compare the total benefit offered by different states, this study introduces a methodology to monetize all major direct and indirect incentives. This paper is the first to monetize specific consumer-oriented U.S. state-level incentives, including purchase subsidies, license tax and fee reductions, annual fees for EVs, electric vehicle supply equipment financing, free electricity at public chargers, free parking, and emissions testing exemptions. We also make first attempts at quantifying the indirect incentives associated with carpool vehicle lane access, emissions testing exemption time savings, and range confidence from public charger availability.

Figure ES-1 summarizes the various electric vehicle consumer benefits and the sales shares for the ten states with the largest consumer incentives for PHEVs and BEVs. As shown, the average incentive offered PHEV and BEV purchasers across the U.S. is less than \$1,000 per vehicle, whereas states like Colorado, Illinois, Louisiana, and California offer \$2,000–\$6,000 per vehicle in incentives. Some states, like Georgia and Washington, offer some of the largest benefits in one category, but not both. In several states with major incentive policies in place—California for both PHEVs and BEVs, Georgia for BEVs, and Hawaii for BEVs—electric vehicle market shares are about 3–4 times the national average. On the other hand, as also illustrated, many states (e.g., Colorado, Louisiana, and Illinois) offer high incentives but are still seeing very low electric vehicle deployment.

BATTERY ELECTRIC VEHICLE



PLUG-IN HYBRID ELECTRIC VEHICLE

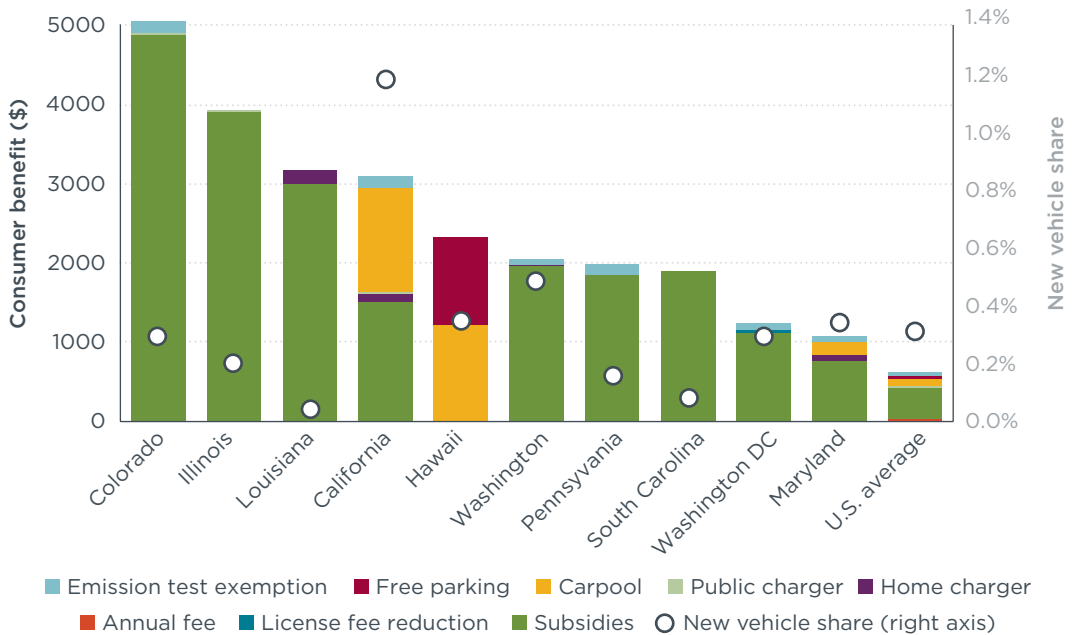


Figure ES-1. Consumer benefit and new vehicle share for U.S. states with largest total battery electric and plug-in hybrid electric incentives (2013 electric vehicle registration data provided by IHS Automotive).

This analysis of state-level electric vehicle sales and policy implementation data point to three key findings and conclusions.

State electric vehicle incentives are playing a significant early role in reducing the effective cost of ownership and driving electric vehicle sales. Some of the states with the largest electric vehicle incentives—California, Georgia, Hawaii, Oregon, and Washington—have electric vehicle sales shares that are approximately 2-4 times the national average. A statistical regression was performed, revealing that the total monetary ben-

efit to consumers from state incentives significantly positively correlates with BEV sales when all 50 states and the District of Columbia are included. These findings suggest that future state efforts to incentivize BEV sales through incentives that substantially drive down the total cost of owning and operating electric vehicles are likely to be effective.

Some types of incentives appear to be more effective in driving electric vehicle sales than others. Based on this novel quantification of many state-level policies, it appears that not all types of incentives affect BEV sales equally. A stepwise regression analysis shows that the most effective incentives are subsidies, carpool lane access, and emissions testing exemptions initiatives. In addition, a basic benefit-to-cost analysis that compares incentives' benefits to consumers to state spending shows that public charger availability is an especially cost-effective incentive for BEV owners, and carpool lane access is cost effective for electric vehicle owners.

Further research is needed to more deeply analyze the impact of other factors on electric vehicle sales. As we show, some state governments offer a wide variety of incentives to electric vehicle consumers, while others have few or no incentives at all, and electric vehicle deployment ranges widely across states. In these early days of automakers introducing new electric vehicles and governments implementing electric vehicle promotion policies, there are still more unknowns than knowns. Many factors remain outside the scope of this state-level assessment. Examples of electric vehicle promotion actions that we did not include are those related to R&D programs, fleet-specific policy, vehicle regulations, low-carbon fuel policy, zero emission vehicle requirements, as well as incentives offered by cities, utilities, workplaces, automakers, and insurance companies. Tracking how the level of automaker marketing activity or the limited geographic electric vehicle roll-out strategies play a role in connecting policy actions to market uptake of the new technology is also a key unexplored question. This study, a snapshot of 2013, does not include how technology costs could decline with battery innovation, greater mass-market economies of scale, or other technical factors. Further study on these factors may help explain how some cities and states are more or less effective at accelerating electric vehicle adoption in the future.

ABBREVIATIONS

AFV	Alternative fuel vehicle
EV	Electric vehicle, including battery electric vehicle and plug-in hybrid electric vehicle
BEV	Battery electric vehicle
DCFC	Direct current fast charger
EVSE	Electric vehicle supply equipment
GHG	Green house gas
HOV	High-occupancy vehicle
PHEV	Plug-in electric vehicle

INTRODUCTION

The U.S. light-duty vehicle fleet is responsible for about half the petroleum consumed and about 17 percent of greenhouse gas (GHG) emissions in the nation (National Research Council (NRC), 2013). Electric vehicles are a critical strategy in reducing petroleum dependence and GHG emissions from road transport (NRC, 2013). In 2013, almost 100,000 plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEVs) were sold in the U.S. (Hybridcars, 2014). However, electric vehicle uptake has lagged policy targets. In order to meet the Obama Administration's goal of one million electric vehicles in the U.S. fleet by 2015, the market share would have to increase from less than 1% in 2013 to roughly 6 percent of the auto market (Rascoe & Seetharaman, 2013).

One reason for the slow uptake of electric vehicles is their higher cost compared to conventional vehicles. For example, the Manufacturer's Suggested Retail Price of the 2013 Nissan LEAF is \$28,880, while that of the comparable Nissan Sentra is \$15,990 (Cars.com, 2014). Lower operating costs, especially in terms of electric vehicles' reduced fuel and maintenance costs, can reduce the total cost of owning and operating plug-in electric vehicles (Electric Power Research Institute (EPRI), 2013). However, depending on the exact vehicle pricing and specifications, vehicle ownership period, annual vehicle use patterns, and other factors, electric vehicle fuel savings may not be sufficient to overcome the upfront price differential for most mainstream consumers. In addition, the long recharge time and shorter range of electric vehicles limit the potential consumer base for BEVs especially, but there is still room for the electric vehicle market to grow as the new technology's lifetime costs decline.

Various forms of policy incentives can contribute to making electric vehicles more attractive to consumers (see, e.g., Collantes & Eggert, 2014). Direct subsidies, such as tax credits and rebates, or indirect incentives, such as carpool lane access and public charging infrastructure, can reduce the effective total cost of electric vehicle ownership through direct financial savings and through time savings. The U.S. federal government offers a tax credit for up to \$7,500 for electric vehicles, substantially reducing the purchase price (U.S. Internal Revenue Service (IRS), 2014). Before 2014, it also offered a tax credit of up to \$1,000 for charger installation in homes and up to \$30,000 for businesses. State governments are offering an additional suite of direct and indirect incentives to electric vehicle consumers. As more and more states consider adding electric vehicle incentives, it is important to examine state-level policy actions' relative impact at driving down electric vehicle costs and driving electric vehicle sales.

This paper seeks to answer this question by comparing the total monetary benefit available to consumers through U.S. state incentives to electric vehicle sales in those states in 2013. Along the way, this work systematically collects information on all the state-level electric vehicle promotion policies at play in the U.S. In order to quantitatively compare the total benefit for electric vehicle consumers offered by different states, this study introduces a methodology to monetize the major direct and indirect incentives.

This work builds on a previous study that suggested fiscal incentives could potentially be driving electric vehicle sales on a national level when comparing countries around the globe but did not include the value of sub-national level and indirect incentives to consumers (Mock & Yang, 2014). Few previous attempts have been made to monetize indirect incentives such as high-occupancy vehicle (HOV, i.e. carpool lane) access and public charger availability. Lin & Greene (2011) made a contribution to this area with an

assessment of the potential impact of improved recharge availability and range anxiety alleviation on electric vehicle market development. A report from the Transportation Energy Futures project (Stephens, T., 2013) discussed non-cost barriers to consumer adoption of new light-duty vehicle technologies. In addition, several recent policy works have begun to catalogue policy action and distill best practices from states and cities to promote electric vehicle readiness (see, e.g., U.S. DOE (2014) and ZEV Program Implementation Task Force (2014)). These studies have been helpful in addressing certain quantitative and policy issues, but to the best of our knowledge no previous attempts have been made to monetize specific incentives offered across U.S. states.

The paper first presents a summary of our review of various direct and indirect electric vehicle incentives available to consumers at the state level in the U.S. In the following section, we describe our methodology to quantify the effective consumer benefits from the various state-level direct and indirect electric vehicle incentives. In the analysis, we conduct statistical regressions and present a comparison between total incentive value and electric vehicle sales. The discussion section provides in-depth analysis on specific state policies. Finally, conclusions are presented.

OVERVIEW OF STATE-LEVEL EV INCENTIVES

The focus of this study is on benefits provided by state governments to individual electric vehicle consumers in 2013. We include direct incentives, as well as indirect incentives that require an additional level of analysis to quantify their monetary impact on electric vehicle consumers. This section describes the basic features of the state electric vehicle incentives that are included in this study and some examples of the policies. Main sources of information on electric vehicle-related incentives in each state are utilized in this work, most notably U.S. Department of Energy's Alternative Fuels Data Center (AFDC, 2014c) and various state government websites. Information on emission test requirements is sourced largely from DMV.ORG (DMV.ORG, 2014) as well as state Department of Motor Vehicles (DMV) websites. A full list of references is included in Annex A.

We note that many electric vehicle promotion policies are outside the scope of this study. Incentives for research and development (R&D), fleets and businesses, workplaces, and incentives offered by utilities and private companies are not included in our analysis, but are summarized in this section to give a fuller picture of the varieties of measures that governments and other organizations have taken to expand the electric vehicle market share. Local incentives at the county and city level, as well as federal incentives, are not included. Other examples of electric vehicle promotion actions that we do not discuss are those related to vehicle regulations, low-carbon fuel policy, zero emission vehicle requirements, utility or workplace incentives, and automaker marketing efforts.

DIRECT INCENTIVES

Direct incentives are those that have a direct monetary value to consumers, reducing payments electric vehicle owners would otherwise have been required to make. The direct incentives that we consider in this study are purchase subsidies, license tax/fee reductions, Electric Vehicle Supply Equipment (EVSE) financing, free electricity, free parking and emission test exemptions.

Purchase subsidies

Purchase subsidies are usually offered in the form of tax credits and rebates, either for electric vehicles specifically or for alternative fuel vehicles (AFVs) generally. Subsidies generally impact both buying and leasing. In the case of leasing, the subsidy stays with the leasing company, and in most cases, it has been factored into the cost of the lease to benefit the customer (Dell, 2011). For example, the federal income tax credit is incorporated into the monthly lease payment, thus avoiding the paperwork and up to 15 months of waiting for a refund (Voelcker, 2013). A California study (Tal & Nicholas, 2013) has found that 71% of the sample of 3,800 PEV owners who acquired their car from early 2012 bought the car and only 29% leased it. The same study found that out of the three main models, Volt owners have the highest lease share at 38%, compared to the LEAF lease share of 31% and the Plug-in Prius lease share of 18%. The timeline for the refund can also affect the consumer benefit. Tax credits may take up to a year, while rebates generally take a shorter time. For example, California's rebate checks are issued within 90 days of application approval (Center for Sustainable Energy, 2014). Some states offer the same subsidies to all types of electric vehicles, some provide a different amount to PHEVs and BEVs (sometimes based on battery capacity), and others offer the benefit only to BEVs. Examples are Illinois's Alternative Fuel Rebate Program, which provides 80% of the incremental cost of purchasing an AFV, up to \$4,000; California's Clean Vehicle Rebate Project, which offers

\$2,500 for BEV and \$1,500 for PHEV purchases; Colorado's innovative motor vehicle credit, which offers up to \$6,000 based on battery capacity and purchase year; and Georgia's income tax credit for zero-emission vehicle (ZEV) purchases of 20% of the vehicle cost, up to \$5,000. In addition to income tax credits, purchase subsidies include state sales tax exemptions for electric vehicle purchases and related services. For example, New Jersey offers a sales and use tax exemption for the purchase, rental or lease of a ZEV, and the District of Columbia (D.C.) has an excise tax exemption for high fuel economy vehicles. Note that subsidies for electric vehicle conversions (e.g., in Colorado, Illinois, Louisiana and Montana) are not considered here. Based on our research, 12 states include some kind of purchase subsidy for electric vehicles that is included in this analysis.

License tax and fee reductions

This category includes license tax reductions and registration fee reductions. For example, D.C. offers a \$36 reduction in the registration fee for new motor vehicles with a U.S. Environmental Protection Agency (EPA) estimated average city fuel economy of at least 40 miles per gallon. Arizona, D.C., and Illinois offer this type of incentive.

EVSE financing

Many states offer subsidies for home chargers and public chargers in the form of tax credits, rebates, and grants. Generally, a state covers a percentage of the cost, capped at a certain amount. Some states subsidize both hardware and installation cost, while some only subsidize hardware or only installation cost. Some examples are given below. For home chargers, Maryland offers an income tax credit equal to 20% of the cost of qualified EVSE, with a cap of \$400 or the state income tax imposed for that tax year. Georgia offers a subsidy for business enterprises that install public chargers, worth 10% of the cost of the charger and its installation or \$2,500, whichever is less. The EV Infrastructure Rebate Program in Illinois covers 50% of the cost of equipment and installation, with a cap depending on types of stations; more than \$350,000 was awarded in 2013, funding a total of 130 stations in that program. Based on research into the state electric vehicle charging infrastructure programs, we included 13 states' EVSE programs.

Free electricity

When charging at a public Level 2 charging station¹, electric vehicle owners often benefit from free electricity that they otherwise would have paid for at home, especially when using a charger owned by the state or city. For example, Washington allows electric vehicles to be charged at no cost at state office locations. A 2013 survey reported that 90% of electric vehicle owners in California had access to free public chargers (California Center for Sustainable Energy (CCSE), 2013). There are about 8,000 public Level 2 stations in the U.S. as of 2013 (AFDC, 2014a). Among these, about 2,000 are free non-networked stations. Many of the 3,000 stations in the ChargePoint network are free (Berman, 2014). With the exception of Tesla's superchargers (free for Tesla owners), most direct current fast chargers (DCFCs)² charge a fee for usage and so the provision of the electricity from DCFCs is not included in this analysis of state incentives. Only Level 2 charging stations are included in the monetization of free electricity as described further below.

¹ Charging equipment for PHEVs and BEVs is classified by the rate at which the batteries are charged. AC Level 2 equipment (often referred to as Level 2) charges through 240V (typical in residential applications) or 280V (typical in commercial applications) electrical service, and adds about 10-20 miles of range per hour of charging time (AFDC, 2014b).

² Typically 480V DC input, adding 60 to 80 miles of range in about 20 minutes (AFDC, 2014b).

Free parking

Two states provide free parking for electric vehicles. In Hawaii, electric vehicle drivers can park at meters free of charge (except under specific circumstances). Nevada requires all local authorities with public metered parking areas to establish a program for AFVs to park in these areas without paying a fee. The decal (label) for the parking fee exemption is less than \$10 per year. We acknowledge but do not include all electric vehicle parking incentives. For example, Hawaii requires public parking systems with one hundred parking spaces or more to include at least one electric vehicle designated parking space and provide an electric vehicle charging system, but this incentive is not included in our analysis. We also, for example, did not include free parking in carpool lots for AFVs in Arizona. In addition to state-level incentives, several local authorities provide free parking for electric vehicles that were not included in this analysis, for example, in San Jose, Sacramento, Santa Monica and Hermosa Beach in California, and New Haven in Connecticut.

Emissions testing exemption

Twenty states require annual or biennial emissions inspections and exempt electric vehicles, and thus electric vehicle owners do not need to pay for the inspection fees required of other vehicle owners. For example, Connecticut exempts electric vehicles from a required biennial emissions inspection, which typically costs \$20. A few states, including Indiana and New Jersey, offer free inspections, while others, such as Missouri and North Carolina, only require testing in major urban areas.

INDIRECT INCENTIVES

Indirect incentives are those that do not have a direct monetary value to the consumer. Rather, these incentives save time and provide convenience, which are sometimes much valued by consumers. Indirect incentives include high-occupancy vehicle (HOV, i.e. carpool lane) access, emissions testing exemption time savings, and public charger availability.

Carpool lane access

Ten states offer unrestricted access to HOV or carpool lanes for electric vehicle drivers. California and Florida also exempt electric vehicles from toll charges on high occupancy toll (HOT) lanes, sometimes called 'express lanes' (essentially HOV lanes that single occupancy vehicle drivers can access by paying a toll). Access to HOV and HOT lanes saves electric vehicle drivers time as these routes are typically less congested during peak hours than other lanes. Some states require a separate sticker, decal, or license plate to use HOV lanes, which usually cost a small amount of money. We note that HOV access stickers can be limited in numbers and command a substantial effective cost among used vehicles with a valid sticker (Blanco, 2009)

Emissions testing time savings

As mentioned above, 20 states offer exemptions from vehicle emission inspections for users of electric vehicles. Exemption from emissions testing saves electric vehicle owners time in addition to not paying a fee.

Public charger availability

Because electric vehicles typically have a lower driving range than conventional gasoline or diesel vehicles, consumers may not feel comfortable driving long distances without recharge capability. Availability of charging stations can provide consumers range

confidence and preclude the need to rent a longer-range vehicle on days when driving longer distances is necessary. Eight states provide funding or other financial incentives for the installation of publicly available chargers.

DISINCENTIVES

Annual fee

In recent years, some states have begun to charge electric vehicle drivers an annual fee to make up for lost gasoline tax revenue. States that have enacted such legislation in 2013 include Nebraska (\$75 per vehicle), Virginia (\$64) and Washington (\$100, for BEVs but not PHEVs). Similar fees are effective from 2014 onward in Colorado (\$50) and North Carolina (\$100) and are not considered in this analysis.

SUMMARY OF INCENTIVES

As shown in Table 1, the direct incentives that we have covered in this analysis are subsidies, license tax/fee reductions, annual electric vehicle fees, EVSE financing, free electricity offered at public Level 2 chargers and emissions testing exemptions, and the indirect incentives are high-occupancy vehicle lane access, emissions testing time savings and public charger availability. All incentives except public charger availability apply to both BEVs and PHEVs. As PHEVs may refuel at conventional gasoline stations, it is assumed that PHEV drivers do not experience range anxiety. Some incentives may give a different level of benefits to BEVs versus PHEVs, for example, a higher subsidy for BEVs than PHEVs in some states. These cases are taken into account and treated individually in the analysis.

Table 1. Incentives applied to BEVs/PHEVs

Type	Incentive	BEV	PHEV
Direct	Subsidies	✓	✓
	License tax/fee reduction	✓	✓
	EVSE financing	✓	✓
	Free electricity	✓	✓
	Free parking	✓	✓
	Emissions testing exemption	✓	✓
Indirect	Carpool lane access	✓	✓
	Emissions testing time savings	✓	✓
	Public charger availability	✓	
Disincentive	Annual electric vehicle fee	✓	✓

OTHER INCENTIVES

State governments and other organizations utilize a wide variety of resources and approaches to help expand the market of electric vehicles. Some major categories of incentives that were researched but not included in this quantitative evaluation are mentioned below.

Zero Emission Vehicle (ZEV) programs

California adopted the first state ZEV program in 1990, which now requires that electric vehicles constitute 10% of all vehicle sales in the state in 2025 (Transportpolicy.net,

2014). Nine other states (Oregon, Maine, Vermont, New York, Massachusetts, Rhode Island, Connecticut, New Jersey, and Maryland) have since adopted ZEV programs (C2ES, 2014). Although we were unable to include ZEV programs in our monetization analysis, this may be a rich area for future research.

Incentives provided by utilities

Some utilities offer discounted or time-of-use (TOU) rates for electric vehicle charging for charging at off-peak hours. TOU rates can reduce costs for electric vehicle owners who recharge at night. For example, the Maryland Public Service Commission has established two pilot programs for electricity customers to charge electric vehicles at lower rates during off-peak hours, offered by Pepco and Baltimore Gas and Electric. The Los Angeles Department of Water and Power, Georgia Power, and Hawaiian Electric Company offer similar TOU rates. Some utilities, such as the Orlando utilities commission, also offer rebates for home and commercial charging stations (AFDC, 2014c).

Incentives for electric vehicle fleets

Several states offer monetary incentives for electric vehicle fleets, many in the form of vouchers. For example, the California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) offers \$8,000 to \$45,000 vouchers (based on Gross Vehicle Weight Rating) for new medium- and heavy-duty electric vehicle fleets (California Hybrid Truck & Bus Voucher Incentive Project, 2014).

Incentives for businesses and manufacturers

Some states support electric vehicle businesses and manufacturers by providing incentives to expedite the development and encourage the manufacture of electric vehicles. Some of these incentives are specifically for electric vehicle manufacturers, while others are for alternative energy technology and manufacture generally. They come in various forms, for example, job creation tax credits based on employee number, tax credits based on the number of vehicles manufactured, grants, and reduced taxable fair market value of manufacturing machinery and equipment. Other states offer incentives for businesses to offer workplace charging equipment.

Research and development (R&D)

States offer various forms of incentives for R&D of electric vehicles, including grants and loans. Some of these incentives are specifically for electric vehicles, while most are for AFVs or more general programs supporting transportation technologies. Examples include a tax credit for 10% of qualified research expenses in Wisconsin, New York's Transportation Research and Development Funding, and Indiana's Vehicle Research and Development Grants (AFDC, 2014c). California's Alternative and Renewable Fuel and Vehicle Technology Program supports both R&D and commercialization.

Insurance discounts and protections

Several insurance providers in California offer a discount on insurance coverage for electric vehicle owners. For example, Farmers Insurance provides a discount of up to 10% on all major insurance coverage for hybrid electric vehicle and AFV owners (AFDC, 2014c).

Others

State governments offer some incentives that are not captured in the categories above. For example, Delaware provides a vehicle-to-grid energy credit in which retail customers can receive electricity credits for energy discharged from an electric vehicle battery to the grid at the same rate that the customer pays to charge the battery (AFDC, 2014c). As another example, in D.C., some certified clean fuel vehicles are exempt from measures that restrict vehicle usage based on temporal considerations, such as time-of-day and day-of-week restrictions and commercial vehicle bans (AFDC, 2014c).

METHODOLOGY TO QUANTIFY ELECTRIC VEHICLE POLICY BENEFITS

This section describes our approach to quantify the benefits to consumers from the electric vehicle incentives described in the previous section. First, we monetize the direct incentives by evaluating the ‘effective’ benefit available to consumers—for example, if a state covers 50% of the cost of a home charger installation, the effective benefit is equal to half the cost of a typical home charger. Second, indirect incentives are monetized based on the type of benefit provided to consumers, which is assumed to be time savings for HOV lane access and emissions testing exemptions and avoidance of rental car cost for public charger availability. Benefits are calculated over the duration of ownership of the vehicle; this is assumed to be six years based on the average length of time a new vehicle is retained by the purchaser (Polk, 2012).

Purchase subsidies, home Level 2 charger subsidies and one-time registration fee reductions are all assumed to be upfront benefits, with the value of the benefit realized at the time of purchase. Benefits from annual registration fees, annual license fees, annual or biennial emission test fees, free parking, HOV lane access, and the value of public charger availability are summed over a period of six years, assuming a discount rate of 5% per year for future-year benefits. The value of free electricity at public Level 2 chargers is not discounted as it is assumed that electricity prices increase over time at a rate comparable to the discount rate (actual electricity rate increases have been 1.4% to 3.1% per year in recent years (U.S. Energy Information Administration (US EIA), 2014)).

ELECTRIC VEHICLE SALES DATA

The sales dataset used in this study was purchased from IHS, and includes electric vehicle registrations by make and model in each state in 2013. We assume new vehicle registrations as being approximately equivalent to, and synonymous with, vehicle sales over 2013.

DIRECT INCENTIVES

Purchase subsidies

Purchase subsidies include rebates and tax credits, including income tax credits and sales tax exemptions. The subsidies in four states, Colorado, Maryland, Pennsylvania, and South Carolina depend on battery capacity. These credits can be very different for the Prius Plug-in and the Chevrolet Volt, for example. For these states, the level of subsidies is calculated based on a sales-weighted average. The majority of the sales in three of the four states (Colorado, Pennsylvania, and South Carolina) are the Volt. The average subsidies for the Volt and Prius Plug-in, respectively, are \$2,516 and \$891 in these four states.

Several states require that a comparable conventional non-electric vehicle be used to estimate the level of subsidy. When a counterpart conventional vehicle is required for calculation of subsidy value, the Nissan Sentra is used. This is determined to be the most similar Nissan vehicle model to the LEAF (see 1.1.1A.1.1 Table 2). 2013 models are used in all cases. For example, the excise tax for conventional vehicles in D.C. is calculated based on fair market value, which depends on gross vehicle weight; in this case, the value of D.C.’s excise tax exemption for electric vehicles is calculated as the excise tax that would be levied on a Nissan Sentra. When the incentive covers a percentage of the cost with a cap, the lesser of these values is used.

Table 2. Characteristics of the Nissan LEAF and Sentra

Characteristic	Leaf	Sentra
Length (in)	175.0	182.1
Internal volume (ft ³)	116.4	111.0
Horsepower	107	130
Torque	187	128
Time from 0–60 mph	10.2	9.1

Sources: Edmunds (2014a,b), zero60times (2014), Plug-in Cars (2014)

License tax/fee reductions

Generally, states reduce the license fee by a certain amount for electric vehicle owners in one or several registration periods. For reductions in first time registration fees such as in D.C., the monetary value of the fee is assumed to be a direct, one-time benefit to electric vehicle owners. For reductions in recurring registration fees, for example in Illinois, the value is discounted accordingly. In Arizona the reduction in license tax for AFVs (including BEVs but not PHEVs) is proportional to the tax for conventional vehicles; here the benefit is calculated as the difference in the total license tax over the average length of ownership time (6 years) between a BEV and its counterpart conventional vehicle.

EVSE financing

Typical costs of chargers are taken as the averages of the ranges given in a study by the Rocky Mountain Institute (Agenbrood & Holland, 2014). This study includes the cost of charging station hardware and installation cost, including other materials, labor, mobilization, and permitting. The average cost of a Level 2 public station is derived from the average costs of curbside and parking garage single stations. The total installed retail cost of a Level 2 home charger, a Level 2 public charger, and a DCFC are estimated to be \$1,175, \$7,250, and \$54,900, respectively. The actual costs of chargers vary depending on specific charger types and labor cost.

A) HOME CHARGERS

If a state only provides a certain amount of subsidy for home chargers, then that amount is used as the benefit. If a state covers a percentage of the cost without a cap, then the benefit is calculated by multiplying this percentage by the typical cost of a home charger. Most state incentives cover a certain percentage of the cost up to a cap. In this case, the benefit is calculated as the lesser of the cap or the percentage multiplied by the typical cost of a home charger.

California survey results are used to estimate the percentage of BEV and PHEV owners who install a home charger. According to CA PEV driver survey results (CCSE, 2013), 90% of all respondents installed a home Level 2 charger. This analysis implicitly assumes that electric vehicle owners would purchase a home charger regardless of the availability of state funding, due to their particular driving habits and preferences. In order to calculate the benefit of home charger subsidies for BEV and PHEV owners separately, it is necessary to estimate the percentage of owners installing home chargers for each vehicle type. 97% of respondents of the CA PEV survey were Nissan LEAF owners and we assume the remaining 3% were mainly Volt owners, since the survey was performed in 2012. 47% of Volt owners installed a home charger according

to Tal, et al (2013). The percentage of Nissan LEAF owners that installed a Level 2 home charger is thus calculated by the following equation, yielding an estimate of 91%:

$$P_{LEAF_hc} = (P_{hc} - P_{volt} \times P_{volt_hc}) / P_{LEAF}$$

Where

P_{LEAF_hc} = percentage of Nissan LEAF owners that installed a Level 2 home charger

P_{hc} = percentage of respondents of CA PEV survey that installed a home charger

P_{volt} = percentage of respondents that are Volt owners

P_{volt_hc} = percentage of Volt owners that installed a home charger

P_{LEAF} = percentage of respondents that are LEAF owners

Average benefits to BEV owners and PHEV owners are derived by multiplying the effective home charger subsidies by the percentage of BEV or PHEV owners who installed a home charger respectively. For example, if a state provides an effective home charger subsidy of \$100, the average benefit to BEV and PHEV owners would be \$91 and \$47 respectively.

B) PUBLIC CHARGERS

The benefits of publicly available chargers to consumers are in providing range confidence and free electricity (discussed below). Both factors are related to the number of public chargers for which that the state provides funding. This subsection details the calculation of the ‘effective number’ of public chargers funded by the state. If a state fully funds a specific number of stations, that number is used. In some cases the state incentive covers some but not all of the cost of the installation of a publicly available charger—the remainder of the cost may be covered by businesses, city governments, or other non-state entities. As such, only the fraction of the charger cost paid by the state government is attributed to the state in this analysis. For these cases, the effective number of public chargers that the state funded is calculated as:

$$N_{e_sps} = N_{sps} \times (A_a / C_t)$$

Where

N_{e_sps} = effective number of public stations funded by the state

N_{sps} = number of public stations funded by the state

A_a = award amount

C_t = total project cost

This last term is essentially the percentage of the cost that the state funded. If the total project cost is not given, an estimate is derived from the typical cost of a station. Some states cover a percentage of the cost of the station up to a cap. This is treated the same as in the case of home chargers. In some cases, the number of stations funded by the state in 2013 alone is sometimes not given, and is estimated by multiplying by the total number of public stations in that state by the fraction of state-funded public stations that were installed in 2013. Although consumers benefit from chargers installed before the year 2013, these were not included in this analysis because we estimate the benefit of state funding for electric vehicles in the year 2013 only. This latter term is estimated from data on chargers installed per year available for Illinois’s incentive program, and the total number of public stations in that state is taken from the AFDC database. Calculations above apply to both public Level 2 and DCFC stations.

Free electricity

As discussed in the section on electric vehicle incentives at the state level, most public Level 2 stations are free as of 2013, especially public meters and state/city owned stations. We assume 80% of public Level 2 stations are free, and will continue to be free for at least three years for all states. The monetary value of free electricity is calculated by estimating the amount of electricity used per vehicle owner per year (from average numbers of charging events and average amount of energy used per event for BEV and PHEV owners separately). We use data on the charging patterns of LEAF and Volt owners collected by the EV project to estimate charging frequency and energy consumption of BEV and PHEV owners. The equation for calculating the benefit of free electricity is:

$$B_e = N_{ce} \times P_{L2} \times E_v \times R_e \times D \times P_{fs} \times Y \times (N_{sL2} / N_{L2})$$

Where

B_e = benefit of free electricity for electric vehicle owner

N_{ce} = average number of charging events per day

P_{L2} = percentage charging events at public Level 2 chargers

E_v = average energy charged per event

R_e = electricity rates

D = days per year (365)

P_{fs} = percentage of stations that are free

Y = years of free charging

N_{sL2} = number of state-funded public Level 2 stations

N_{L2} = number of all public Level 2 stations

The first three terms of the equation are different for BEV and PHEV owners (Schey, 2013; U.S. DOE, 2013a,b). Due to restrictions on data availability, the average energy charged per event at public chargers and the proportion of total charging events per kWh that occurs by LEAFs versus Volts are calculated from other data given in EV Project reports (Schey, 2013; U.S. DOE, 2013a,b). The average energy per event at public chargers for BEV owners specifically is calculated as:

$$E_{v_BEV} = kWh_v \times P_{v/kWh} \times P_{kWh_BEV}$$

Where:

E_{v_BEV} = average energy charged per event at public chargers for BEV owners (kWh)

kWh_v = energy consumed per public charging event in kWh

$P_{v/kWh}$ = proportion of charging events per kWh by LEAFs and Volts

P_{kWh_BEV} = percentage of all kWh consumed at public stations by BEV owners

And where:

$$P_{v/kWh} = (P_{v_BEV} + P_{v_PHEV}) / [(P_{v_BEV} \times P_{kWh_BEV}) + (P_{v_PHEV} \times P_{kWh_PHEV})]$$

$P_{v/kWh}$ = proportion of charging events per kWh by LEAFs and Volts

P_{v_BEV} = percentage of all charging events at public stations by BEV owners

P_{v_PHEV} = percentage of all events at public stations by PHEV owners

P_{v_BEV} = percentage of all charging events at public stations by BEV owners

$P_{\text{kWh_BEV}}$ = percentage of kWh consumed at public stations charged by BEV owners

$P_{\text{v_PHEV}}$ = percentage of all charging events at public stations by PHEV owners

$P_{\text{kWh_PHEV}}$ = percentage of kWh consumed at public stations by PHEV owners

To calculate the benefit of free electricity for PHEV owners, the relevant terms in the equation are substituted with PHEV-specific data. This benefit is not discounted as mentioned before because the electricity rate is assumed to increase over time.

Free parking

Two states, Hawaii and Nevada, offer free parking to electric vehicles. For both states, we assume that parking is a real benefit only in major population centers and urban areas, which are Oahu and Hawaii Island in Hawaii, and Las Vegas and Reno in Nevada. The weighted hourly parking rate for a state is derived by multiplying the typical hourly rate in each urban area (i.e., county or city) by the percentage of the state's population that resides in that area, and summing the contribution of all areas. For example, the typical hourly rates in Oahu and Hawaii islands are \$1 and \$0.5 respectively, and their populations are 72% and 12% of the total population in Hawaii. The weighted hourly parking rate for the state would thus be \$0.78 (i.e., \$1 x 72% + \$0.5 x 12%).

The typical rate at meters or municipal parking lots is used to represent the hourly rate of parking in each area (Parkopedia, 2014; Downtown parking finder, 2014; Hawaii Department of Accounting and General Services, 2014; Lee, 2013). State population and area population data are taken from the U.S. Census Bureau (U.S. Census Bureau, 2014). An assumption is made that an average electric vehicle owner would park at meters or municipal parking lot for 5 hours per week, and this is used to calculate the total monetary benefit of free parking to an electric vehicle owner in a year. This assumption is roughly consistent with survey results showing that 21% of Honolulu residents and 10% of Hawaii Island residents pay for parking at work or school (Coffman & Flachsbar, 2009). This value is discounted in the 5 years following the year of the vehicle purchase and summed to give the total monetary benefit over the length of time of ownership.

Emission test exemption

In some states, electric vehicles are exempted from the compulsory emissions testing required for most conventional vehicles, saving both money from the test fee and time spent during testing (time savings is discussed under Indirect incentives below). This benefit is not taken into account for states that do not require emissions testing for any vehicle. We use the typical fee (DMV.ORG, 2014) or the maximum fee of an emission inspection as the fiscal value of this benefit per electric vehicle owner for the first year. A few states do not require emissions testing for any new vehicles for the first few years; this exemption for new conventional (i.e., non-electric) vehicles in these cases is not considered in this analysis. Some states only require emission testing in some counties, which usually include major metropolitan areas. In this case, we multiplied the emissions test fee by the percentage of the state's population that is urban (U.S. Census Bureau, 2011) to approximate the percentage of drivers who reside in areas requiring emissions testing. Examples are Colorado and Pennsylvania. Emissions tests are generally required either annually or biennially, and testing fees after the year of purchase are discounted accordingly.

INDIRECT INCENTIVES

Carpool lane access

The main benefit of carpool lane access for electric vehicles is time savings, as carpool, or HOV, lanes are typically less congested than non-HOV lanes on similar routes, and thus allow reduced commute time. The value of the effective benefit of access to the carpool lane for a single-occupancy electric vehicle user varies greatly. This benefit is approximated for each state offering carpool lane access incentives based on factors including states' overall congestion, population in applicable metropolitan areas, availability of carpool lanes, and the relative relief offered for use of the HOV lanes. Congestion cost estimates by city were used to estimate the cost of time spent in traffic and thus the monetary benefit of time savings. In some cities with several HOV lanes on key congested routes, HOV access may alleviate a large fraction of a typical commuter's congestion cost, while in others with few or poorly placed HOV routes, this benefit may not be as important. In order to account for this, we estimate the percent of congestion avoided through HOV access. We also consider the percentage of each state's population that resides in metropolitan areas with HOV lanes and may thus benefit from HOV access. The benefit per consumer of HOV access is calculated based on the equation:

$$V_{\text{HOV}} = \text{sum across cities } [(P_t \times (POP_m / POP_s))] \times C_c \times P_r$$

Where:

V_{HOV} = value of HOV lane access for electric vehicles

P_t = percent traffic alleviated by HOV access

POP_m = metropolitan population

POP_s = state population

C_c = congestion cost

P_r = percent HOV relief

Percent traffic alleviated by HOV access is estimated as the percent of congested highways in a metropolitan region that have HOV lanes. This is roughly calculated as the number of roads with HOV lanes that had significant traffic during the weekday morning rush hour divided by the total number of state and interstate highways with significant traffic in the metropolitan region. Congestion cost is taken from TTI's Urban Mobility Report (Schrank et al, 2012), which is based on time spent in traffic in each city and other factors. Percent HOV relief is a rough approximation factor that is included to account for the fact that only some fraction of congestion during an average commute occurs on highways and may thus be relieved by HOV lane access (i.e. drivers may experience congestion on smaller roads that were not included in the analysis). We apply a 50% HOV relief factor in this analysis.

Our approach for estimating the percent of traffic alleviated by HOV access is as follows. First, we take Google map traffic images of each city during rush hour (8:30–9am local) on five separate weekdays. Second, the number of HOV routes in the metropolitan region with at least 25% traffic is counted, indicated by yellow or red sections on Google maps. Then, the number of interstate and state highways in the metropolitan region with at least 25% congestion is counted. Last, we divide the number of congested HOV roads by the total number of congested highways in a metropolitan area, which gives us the percentage of traffic alleviated by HOV access.

For California, extremely short HOV lanes (i.e., those less than 5 miles) are excluded. Ten percent toll discounts during off-peak hours on the New Jersey Turnpike and New York State Thruway were also excluded since these discounts are small and variable (depending on travel length) and these routes appear to have low travel volume compared to most HOV lanes analyzed here. Plate and sticker fees are subtracted from the final benefit of HOV lane access (discounted if they are annual fees).

We compared the benefit calculated with this approach to results with other estimates of the value of HOV access in California. In California, a hybrid vehicle with a HOV sticker was worth about \$1,200 more than one without a sticker in 2009 (Blanco, 2009), which is equivalent to about \$1,300 in 2013 dollars according to the U.S. Bureau of Labor Statistics CPI inflation calculator. In our analysis, we calculate the HOV lane access benefit to be around \$1,400 for a 6-year period in California; this monetary benefit is very similar to the \$1,300 price premium of hybrid with a HOV sticker. We also calculate the value of HOT access based on HOT lane toll rates in California and Florida, and these values are within 5% difference of our results on average.

Emissions testing exemption time savings

Here, the benefit of time savings is essentially the value of the time saved that is not required for the emissions tests. According to the U.S. Department of Transportation guidance (U.S. DOT, 2011), the recommended hourly values of surface modes travel time savings is \$12.50 for all purpose local travel and \$18.00 for all purpose intercity travel. The average is \$15.25 in 2009 dollars per person-hour, which is \$16.6 in 2013 dollars; this value is used here. We assume that the time savings of an emissions testing exemption is half an hour, which results in a \$8.30 monetary value for an emissions testing exemption. This value is discounted for years after the year of purchase. Unlike the direct benefit of emissions testing exemption, this indirect benefit also applies to states like New Jersey and Ohio, which offer free inspections.

Different people value their time differently. While it may be true that BEV/PHEV buyers have generally higher income than average at present, and their time may be deemed more valuable, we did not attempt to account for this in this analysis, instead opting to value all motorists time consistently, as described above. We note though that this approach is more conservative in approximating a lower monetary benefit than assuming a higher-than-average value of time.

Public charger availability

The value of increased range confidence from increased electric charger availability is approximated for BEVs but not for PHEVs. As PHEVs may refuel at conventional gasoline stations, it is assumed that PHEV drivers do not experience range anxiety.

Deployment of public chargers to improve range confidence reduces the probability that daily travel could exceed the effective range of the vehicle. The benefit for the median driver under ideal charger availability is adjusted from a study that calculated days of insufficient range of EVs based on BEV drivers' daily travel distance distributions from National Household Travel Survey 2001 data (Lin & Greene, 2011). This study also gave a monetary value for range confidence by assuming a \$15 penalty per day of insufficient range. The upper bound of this daily penalty is the daily rate of a rental car based on the assumption that a BEV driver must rent a higher-range vehicle on days of insufficient range. The monetary value for median BEV drivers with a 100-mile range vehicle (representing a Nissan LEAF) in this study is for 10 years with a discount rate of 7%. We

adjusted the results of Lin & Greene to match our assumptions for vehicle retention and discount rate, and adjusted for the actual average cost of a car rental in the U.S of \$51.08 per day (Auto Rental News, 2014). The value of range confidence given in Lin & Greene is based on ideal charger availability, meaning that a BEV owner can charge whenever and wherever needed. As state incentives for publicly available chargers only partially meet this need, the effective number of public chargers supported by state incentives is divided by the number of gasoline stations available in a state. This assumption could underestimate the benefit of charger availability as actual gasoline station availability may exceed ‘ideal availability’ in many locations. Public Level 2 chargers and DCFCs are both included in this analysis. The benefit is summed over 6 years and discounted for years after the year of purchase.

The calculation of this benefit is based on the equation:

$$B_{rc} = B_{med} \times (N_{sps} / N_g)$$

Where:

B_{rc} = benefit of range confidence for electric vehicle owners in the first year

B_{med} = benefit for median driver under ideal charger availability

N_{sps} = number of state-funded stations

N_g = number of gasoline stations in the state

DISINCENTIVES

Annual electric vehicle fee

This term is negative in the benefit analysis since it is a fee paid specifically by electric vehicle owners and not by non-electric vehicle owners. States that imposed a fee on electric vehicles in 2013 include Nebraska (\$75), Virginia (\$64) and Washington (\$100, only applies to BEVs). These values are discounted in future years and summed over 6 years.

BENEFIT-COST RATIO OF INCENTIVES

Here, the benefit that each incentive provides to consumers is compared to the incentive’s cost to the state. This benefit-cost ratio only includes the consumer benefits described above, and does not account for externalities such as health benefits and environmental benefits that electric vehicles provide to society as a whole.

The cost to the state of implementing each incentive is estimated on a per-consumer basis. For direct incentives, the cost is assumed to be equal to the benefit to consumers—for example, awarding a \$2,500 rebate to an electric vehicle consumer costs the state of California \$2,500. The cost of indirect incentives is detailed below.

The cost of HOV lanes per consumer is calculated by spreading the cost of constructing HOV lanes over the total number of people with access (including both electric vehicle owners and conventional vehicle owners who carpool), following the equation:

$$C_{HOV} = C_{const} \times M_{HOV} / \{ [N_{EV} + (N_v \times P_{cp})] \times P_b \} / (Y_{hwy} / Y_{vo})$$

Where:

C_{HOV} = cost of HOV lanes

C_{const} = cost of HOV lane construction

M_{HOV} = HOV lane miles in a state

N_{EV} = total number of electric vehicles

N_v = total number of vehicles

P_{cp} = percentage of all commuters that carpool

P_b = percentage of all commuters that benefit from HOV lanes

Y_{hwy} = lifetime of the highway

Y_{vo} = length of vehicle ownership

And where the percentage of commuters that benefit from HOV lanes is defined as:

$$P_b = P_{pc} \times P_t \times (POP_m / POP_s) \times P_r$$

Where:

P_b = percent age of all commuters that benefit from HOV lanes

P_{pc} = percentage of people who commute by private car

P_t = percent traffic alleviated by HOV access

POP_m = metropolitan population

POP_s = state population

P_r = percent HOV relief

HOV lanes are generally newly constructed. California and North Carolina explicitly state that “regular mixed-flow lanes are never converted to HOV lanes. Rather, HOV lanes are always added to existing facilities” (CA DOT, 2014; NC DOT, 2014). Simply converting existing general traffic lanes to HOV lanes would result in greater congestion for the remaining general traffic lanes. Therefore, we assume new construction for HOV lanes in all states here. One study (Railstotrails, 2008) summarizes the cost of adding a single lane to an existing highway based on a 2003 FHWA study. The model in this study assumes higher construction costs in areas where widening might be especially difficult or costly, such as densely developed urban areas or environmentally sensitive rural areas. These ‘high cost lanes’ can cost from \$7.3 million to \$15.4 million per lane-mile for construction in urban areas and from \$5.8 million to \$9.9 million per lane-mile in rural areas. Since our analysis is focused on HOVs in major metropolitan areas, the average cost of these ‘high cost lanes’, which is \$9.6m per lane-mile, is used as the cost of constructing HOV lanes. Actual cost of a project varies depending on geographic location, terrain type, development type, and other factors. For example, the SR 16 HOV lane improvements in WA cost \$3.1m per lane mile, while the I-5 Tacoma HOV lane cost \$14.5m per lane mile (WA DOT, 2014). In addition, only the initial construction cost is assumed here; maintenance and other improvement cost are not included. Data on HOV lane miles in a state are largely taken from state and federal government websites.

As detailed above, the total number of electric vehicles in each state is calculated based on the percent of all electric vehicles rebates that were claimed in 2013 in California (CVRP rebate data). The total number of vehicles is calculated as vehicle registrations in 2009 (U.S. Federal Highway Administration, 2011) multiplied by average vehicle survivability, which is 13 years (Lu, 2006). The percent of Americans who carpool (Statisticbrain, 2014), which is 10%, is assumed to be the percent of total vehicles using HOV lanes. A 30-year lifetime of a highway is assumed, and the length of vehicle ownership is 6 years.

We make several other notes regarding our benefit-cost assessment. The percentage of people who drive to work is the sum of the percentage of people who drive to work solo and those who carpool (Statisticbrain, 2014); this totals 88%. The other three terms in the equation are detailed above for the HOV benefit analysis, and the average values of all the states that offer this benefit are used here. The cost of chargers is based on the number of effective chargers funded by a state multiplied by the typical cost of a charger. The cost of free electricity is assumed to be half the benefit of free electricity, as some state-funded stations were installed on private properties and thus the cost of free electricity is borne by the private property owner. The cost of emissions testing exemptions to the state is assumed to be zero because the testing fee is typically paid to an independent party. Because the benefit-to-cost ratio of this incentive would be infinite, it is not reported in the results section.

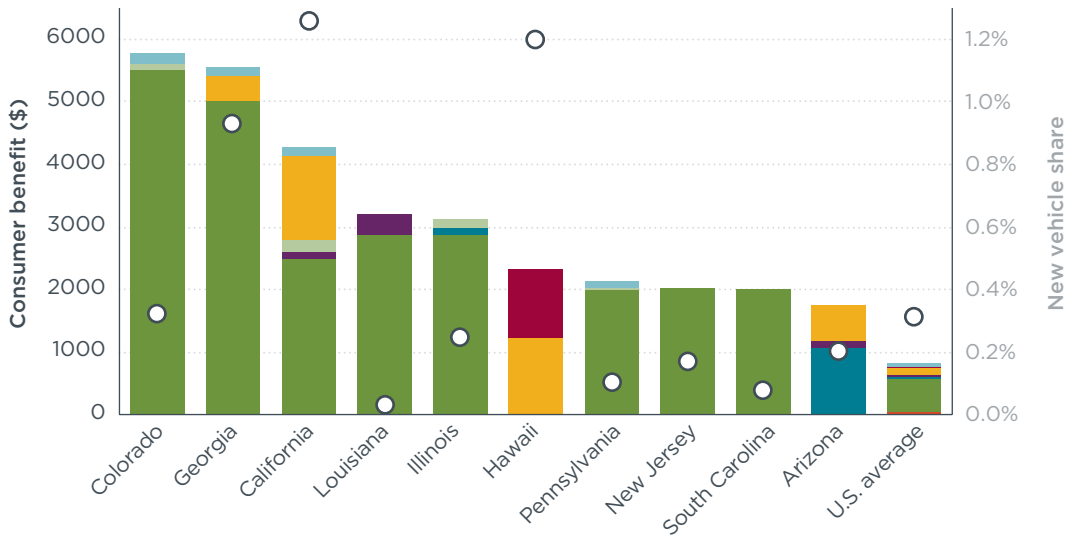
ANALYSIS OF THE IMPACT OF STATE-LEVEL INCENTIVES

This section includes descriptive results from the previous section, including quantification of the direct and indirect benefits of electric vehicle promotion policies across the states. In addition, here the electric vehicle policy and electric vehicle sales data are analyzed for statistical correlations in order to discern the relative impact of the consumer incentive. Finally we provide a basic, first-order benefit-cost analysis of the electric vehicle incentives to provide a measure of the relative cost-effectiveness of the various policies.

VARIATION IN STATE ELECTRIC VEHICLE INCENTIVES

Figure 1 shows the total benefit and electric vehicle sales share for the top 10 states by monetized incentives compared to the U.S. average for BEVs and PHEVs, broken down by incentive type. Some states incentivize both BEVs and PHEVs heavily, and we can see these appear in both top 10 lists: Colorado, California, Louisiana, Illinois, Hawaii, Pennsylvania and South Carolina. There is a large range in the magnitude of total benefits even within the top 10: the highest ranking state (Colorado) provides about three times the total benefit as the 10th state for BEVs, and about five times for PHEVs. The composition of incentives varies substantially across states. For most states, the majority of the monetary benefit is in subsidies. Some states show a more balanced combination of different incentives (e.g. California), whereas states like Hawaii or New Jersey are dominated by one or two kinds of incentives. Arizona and Hawaii do not have subsidies but still make it to the top 10 list by offering combinations of incentives.

BATTERY ELECTRIC VEHICLE



PLUG-IN HYBRID ELECTRIC VEHICLE

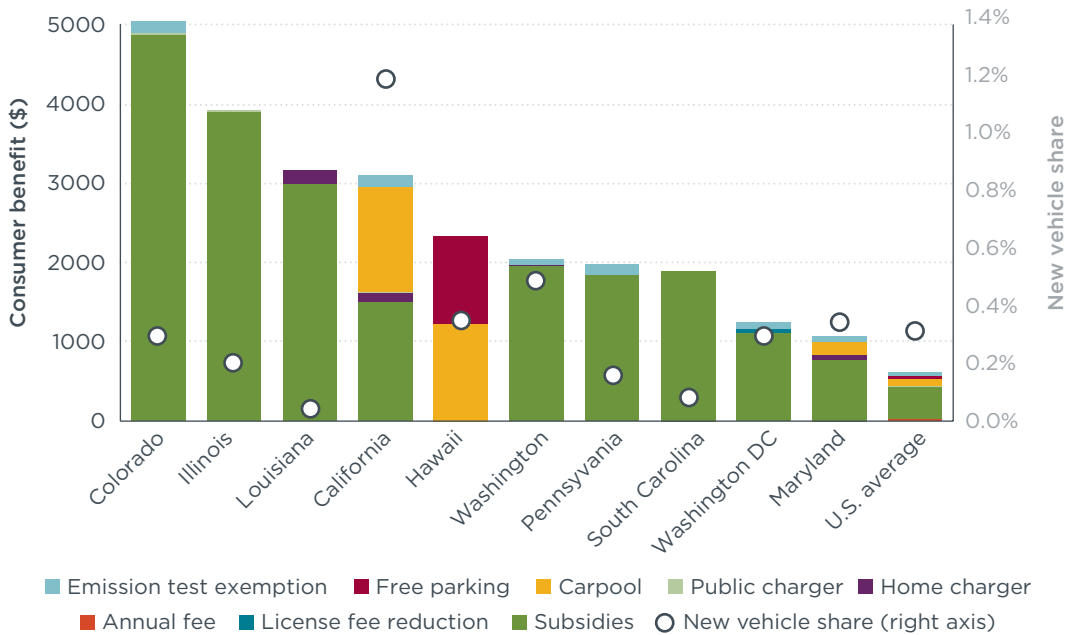
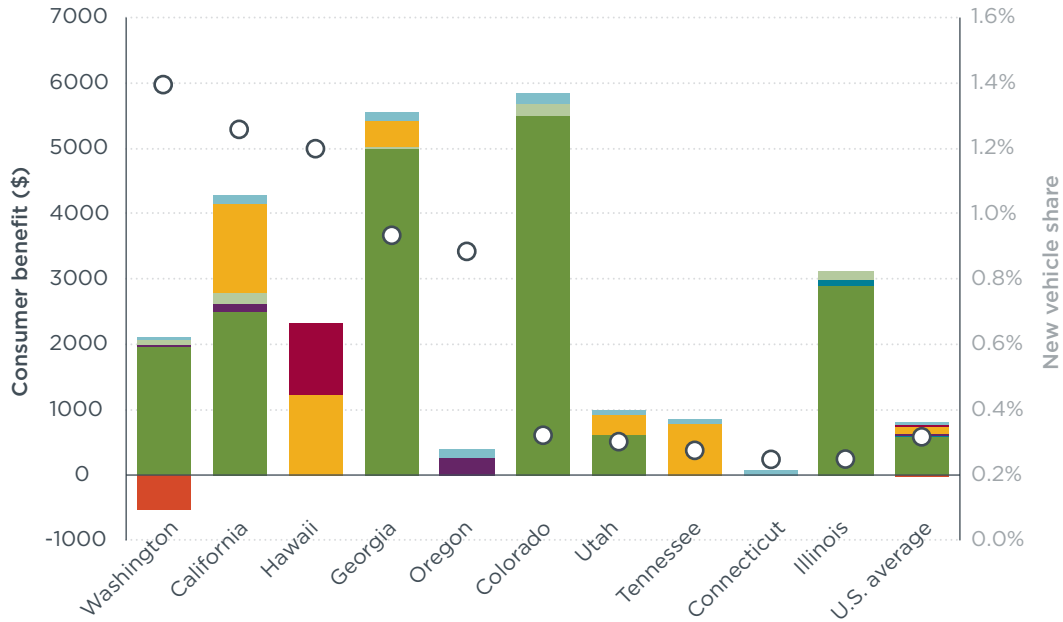


Figure 1. Consumer benefit and new vehicle share for U.S. states with largest total battery electric and plug-in hybrid electric incentives (2013 electric vehicle registration data provided by IHS Automotive).

Figure 2 shows the total benefit and electric vehicle sales share for the ten states with the highest sales share of BEVs and PHEVs. Some states show high BEV and PHEV sales shares and high consumer benefits from state-level policies. However, it is also apparent from this figure that some states have achieved high electric vehicle sales without offering the types of incentives included in this analysis. For example, for BEVs, Oregon in particular has a relatively high sales share (over 0.8%) while providing very little benefit to prospective electric vehicle consumers based on the policies analyzed here. For PHEVs, as shown in the figure, there are several states that are achieving relatively high sales shares with relatively little consumer benefits from the policies analyzed here. Four states ranking in the top ten for PHEV sales shares offer none of the consumer incentives analyzed

here. Especially high BEV sales are seen in five states (i.e., Washington, California, Hawaii, Georgia, and Oregon), while four of the states in the top ten for BEV share are actually below the national average in sales. The distribution of PHEV sale shares in the top-ten states, apart from high sales in California and Vermont, is more even across the states.

BATTERY ELECTRIC VEHICLE



PLUG-IN HYBRID ELECTRIC VEHICLE

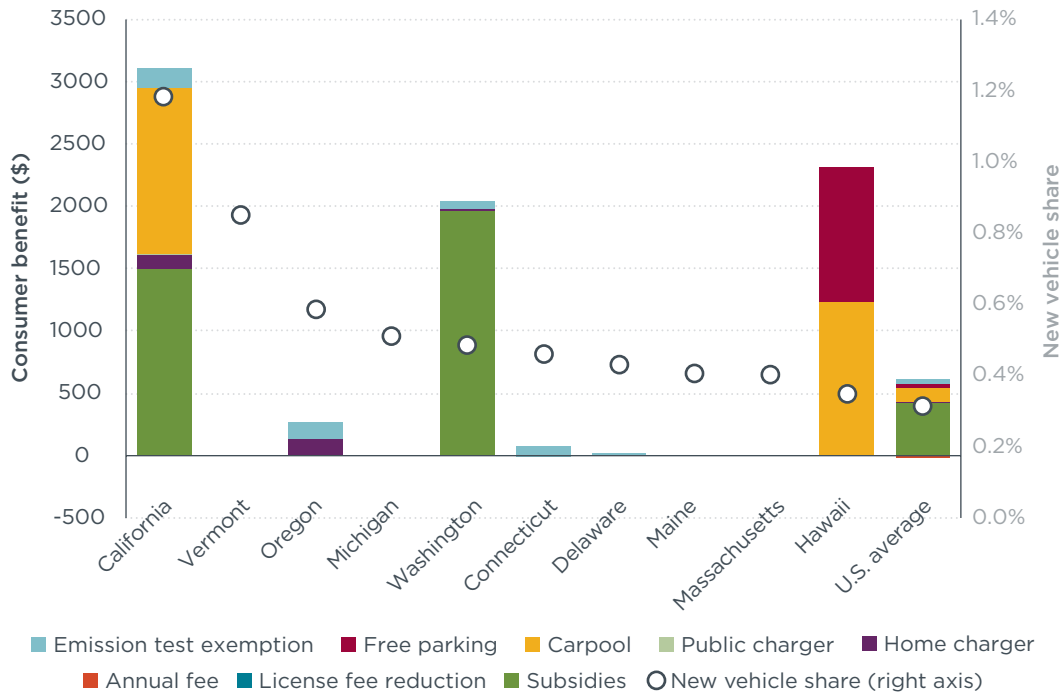
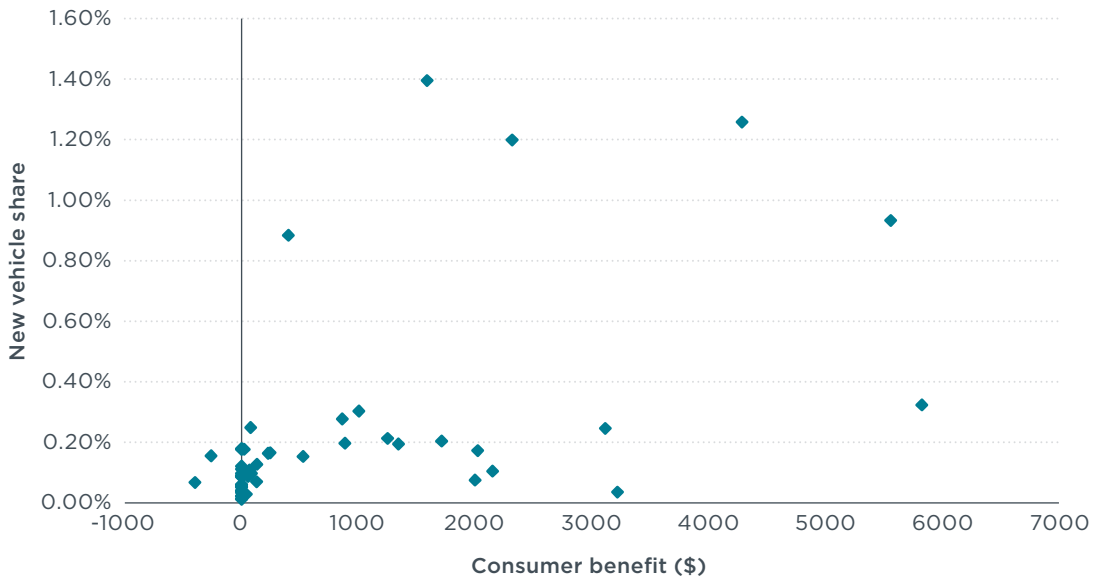


Figure 2. Consumer benefit and new vehicle share for U.S. states with largest total new battery electric and plug-in hybrid electric vehicle shares (2013 electric vehicle registration data provided by IHS Automotive).

Some states that offer high incentives see a larger sales share in sales of electric vehicles than other states. For BEVs, 5 out of the top 10 states are also among the top 10 for sales share (California, Hawaii, Georgia, Colorado and Illinois). For PHEVs, 3 out of the top 10 are among the top 10 for sales share (California, Washington and Maryland). The average sales share of states that have a total benefit more than the national average is 0.51%, and that of states that have a total benefit less than the national average is 0.08%. Figure 3 shows the sales share by total benefit for all states and D.C. Negative benefit values are the result of an annual fee. We see high scatter in the relationship between incentives and sales share. For BEVs, there is a general trend of states that offer a higher total level of benefits exhibiting a higher electric vehicle sale share, but for PHEVs there is not such a clear-cut relationship. As shown in the figure, there are three states for which BEV sales stand out at above 0.8%; these are California, Hawaii, and Georgia. The one state with greater than a 1% PHEV sales share is California, which may be due to that state's Zero Emissions Vehicle program and other state incentives we were not able to capture in the benefit analysis.

BATTERY ELECTRIC VEHICLE



PLUG-IN HYBRID ELECTRIC VEHICLE

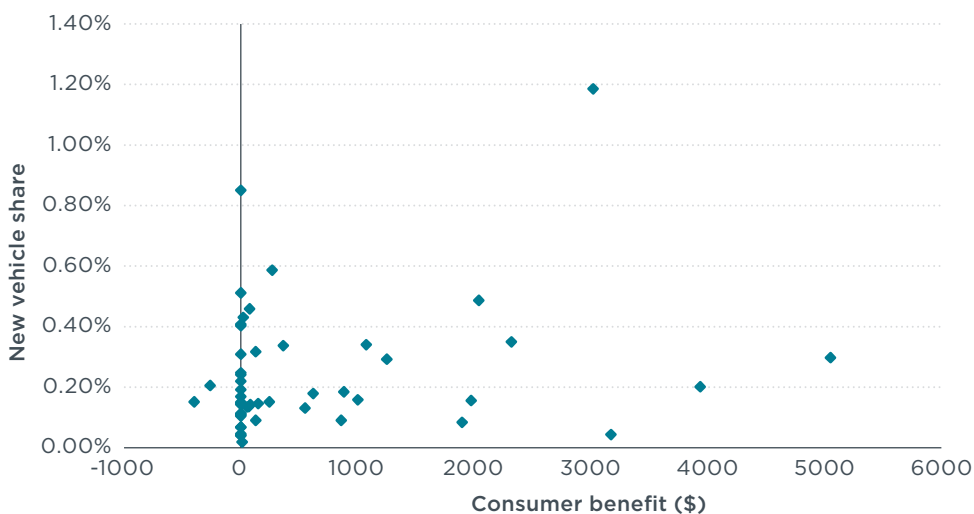


Figure 3. New vehicle share by total available incentive benefit for all states and D.C. for BEVs and PHEVs (2013 electric vehicle registration data provided by IHS Automotive).

STATISTICAL ANALYSIS OF IMPACT OF POLICIES ON ELECTRIC VEHICLE SALES SHARE

A statistical analysis is conducted using stepwise regressions to test the relationship between electric vehicle sales and total benefit for BEVs and PHEVs. A stepwise regression is a bidirectional selection process of building a model by successively adding or removing variables. The selection process starts by adding the variable with the largest explanatory value in the model, according to its t-statistic. Other variables are successively added into the regression; at each step the variable with the strongest effect (lowest p-value) is retained. At each step after the third variable is added, the significance of each previously added variable is evaluated. If their contributions to the model become insignificant (p-value >0.05), the variable with the weakest effect (highest p-value) is removed. The procedure continues until no more variables can be added or removed. The threshold for significance is $p < 0.05$ in this analysis. Multicollinearity was not detected in either regression.

Stepwise regression analysis is performed for BEV and PHEV sales, separately. Two control variables, total vehicle sales and the percentage of residents with an income over \$100,000 in each state (U.S. Census Bureau, 2011) are included in the regression to separate the influence of these variables on electric vehicle sales from the effect of incentives on BEV and PHEV sales. As the benefit and sales datasets are both skewed with values clustered near zero, all variables in the analysis are logged (base 10) to provide an even distribution.

The results of the stepwise regression analyses indicate that total monetary benefit available to BEV owners is significantly positively correlated with BEV sales, but that PHEV benefit is not correlated with PHEV sales. The following discussion focuses on the results for the BEV regression only. Table 3 summarizes the results of this stepwise regression. The coefficients in a log-log transformation reflect the percent change in Y as a result in the percent change in X. In this case, a 10% in the total benefit offered by a state would increase that state’s electric vehicle sales by around 1.8%. The adjusted R^2 for the regression is 0.773.

Table 3. Results of stepwise regression of BEV sales to total benefits

	Coefficient	P value
Intercept	-3.155	< 0.0001
Log (total benefit)	0.185	0.044
Log (total vehicle sales)	0.114	< 0.0001
Log (percent income >\$100k)	1.688	< 0.0001

This relationship can be expressed as:

$$\text{Log(BEV sales)} = -3.155 + 0.185 \times \text{log}(\text{total benefit}) + 0.114 \times \text{log}(\text{total vehicle sales}) + 1.688 \times \text{log}(\text{percent income} > \$100\text{k})$$

A second stepwise regression is conducted for the BEV data, breaking the total benefit apart into eight kinds of incentives (independent variables). The two control variables described above are included. Again, all variables were logged. The purpose of this regression is to compare the effectiveness of the different types of incentives in driving BEV sales.

The regression results indicate that 5 of the 10 variables are significant: subsidies, HOV lane access, emissions testing exemption, annual fee, and total vehicle sales. The adjusted R^2 for the regression is 0.668. Figure 4 illustrates the relative magnitude of the effect of each variable on BEV sales. The higher the absolute value of a coefficient, the greater impact that variable has on BEV sales. The value is zero for insignificant variables. Of all the different types of incentives, subsidies contribute the most to BEV sales share, followed by HOV lane access, emissions testing exemptions and annual fees. As shown, annual BEV-specific fees have a negative impact on BEV sales, while all other four variables have a positive impact.

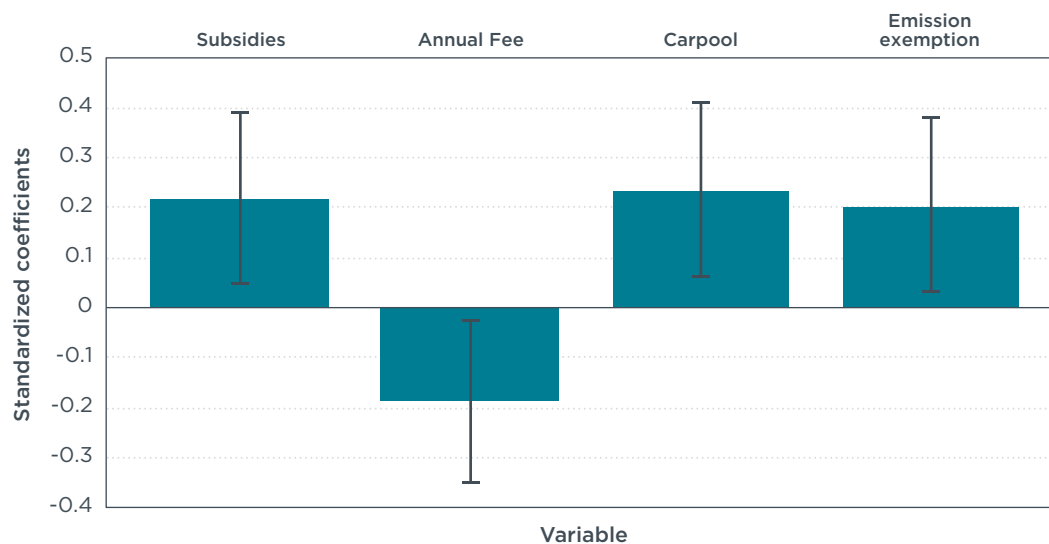


Figure 4. Standardized coefficients of variables in the stepwise regression of BEV registrations to individual incentives in the 50 states and D.C. Error bars show the 95% confidence interval.

RESULTS FROM BASIC BENEFIT-COST ANALYSIS OF STATE-LEVEL POLICIES.

A basic, first-order benefit-cost analysis is conducted in order to provide a measure of the relative cost-effectiveness of the various policies. Only the monetized benefit of each incentive to consumers is considered; environmental, health, and network benefits to society are not included. Table 4 shows approximations for the benefit-cost ratio for BEVs and PHEVs. 'Other direct subsidies' includes subsidies, registration fee exemptions, annual license tax/fee exemptions and free parking. Since most emissions testing is performed by private facilities, emission testing exemptions generally do not affect the revenue of state governments and are thus not included in the graph. For BEVs, the benefit of home chargers refers to home charger subsidies, and that of public chargers includes free electricity and range confidence. For PHEVs, the benefit is the same as BEVs, excluding range confidence.

As shown in Table 4, for BEVs, the public charger benefit has the highest benefit-cost ratio (about 2.5), followed by HOV lane access (about 1.2). This is consistent with the benefit-cost ratio of the I-10 HOV lane, which is estimated to have a benefit-cost ratio of 1.5 from Puente Ave to Citrus St. (4.1 miles), and of 1.2 from Citrus St. to Route 57 (4.9 miles) (Los Angeles County Metropolitan Transportation Authority, 2014). For PHEVs, HOV access has the highest benefit/cost ratio, which is about 1.2. Public chargers have a ratio less than 1 for PHEVs. The largest difference in this benefit-cost

ratio for BEVs and PHEVs is in the approximation of how public charger availability results in greatly increased range confidence for BEV users and how BEVs consume more free electricity from public Level 2 chargers than PHEVs. The benefit-cost ratio of HOV access is estimated to be about the same for BEVs and PHEVs.

Table 4. Ratio of consumer benefit-to-state-cost for major incentive types for BEVs and PHEVs.

	Direct subsidies*	Hov lanes	Public chargers	Home chargers
BEVs	1	1.19	2.45	1
PHEVs	1	1.17	0.41	1

* 'Direct subsidies' includes subsidies, license tax and fee reduction, and free parking

DISCUSSION

To the best of our knowledge, this study is the first attempt to monetize and compare direct and indirect incentives for electric vehicles at the U.S. state level at this level of detail. States offer a wide range of incentives for BEVs and PHEVs, from direct subsidies like rebates and tax credits, to indirect benefits like HOV lane access. After monetizing each of the available incentives, the total level of benefit offered to electric vehicle consumers is found to vary greatly across states. Some of those states offering the highest incentives to BEV and PHEV owners—notably California, Georgia, and Hawaii—appear to clearly be effective in driving electric vehicle sales.

Looking closer at the incentives offered in these states tells us about their strategies for promoting electric drive. For example, the majority of the benefit offered by California and Georgia is comprised of subsidies and HOV lane access together. Following a slightly different strategy, Hawaii complements its strong HOV benefit with free and dedicated parking for electric vehicles, but does not offer direct subsidies like California and Georgia.

Comparing California and states with little EV incentives or sales also helps illustrate the effect of total electric vehicle incentives on sales. California offers an assortment of different benefit types, ranking #3 in the total incentive benefit offered to consumers for BEVs and #4 for PHEVs, and it has the highest electric vehicle sales and sales share overall. Subsidies and HOV lane access, two major incentives offered in California, have a higher benefit-cost ratio than some other incentives. In addition, California's Zero Emission Vehicle (ZEV) program requires that an increasing share of auto sales be electric vehicles in that state and this, as well as similar programs in other ZEV-adopting states, is not included in this analysis. The ZEV program clearly contributes to automakers' deployment and marketing efforts. On the other hand, Mississippi, Oklahoma, North Dakota, and Wyoming are examples of states offering nearly no benefits to electric vehicle owners, and have nearly no EV sales. Whereas California has over 2.4% combined PHEV and BEV sales share, these four low-EV-incentive states each have less than 0.08% combined PHEV and BEV sales share.

Overall, the total monetary benefit to consumers of state incentives is significantly correlated with BEV sales in 2013. In other words, these incentives are effective at driving BEV sales. While the federal tax credit of \$7,500 per vehicle may be thought to be the major factor in consumer decision making in the U.S., our analysis shows that adding up the value of all state incentives together can nearly approach this value for the states that are offering the highest incentives for electric vehicles. Based on this analysis, these suites of state-level incentives are impacting BEV sales. These results suggest that state electric vehicle incentives are playing a significant early role in reducing the effective cost of ownership and driving electric vehicle sales.

Not all types of incentives affect BEV sales equally. A stepwise regression analysis shows that the most effective incentives are subsidies, HOV lane access, and emissions testing exemption initiatives. Public charger availability, home charger subsidies, license fee exemptions, and free parking do not appear to have as strong of an effect on BEV sales, and imposing an annual fee on BEVs to compensate for the gasoline tax is actually effective at *discouraging* EV sales. These results could help explain why, for example, Nevada ranks lower in BEV sales share than Utah, despite having a similar level of total benefits; Nevada relies heavily on free parking (an insignificant driver in this analysis), while Utah offers a purchase subsidy and HOV lane access (significant drivers). However,

caution should be taken in interpreting these specific results. While the correlation between *total* benefits and BEV sales is robust, the regression of sales to individual incentives may be over-fitting our relatively small sample size (51 states) with a high number of variables. Further, we note that the statistical regressions on the relative importance of various policies are based on early, very low numbers of electric drive sales. We note that there are many confounding factors and many other electric vehicle promotion actions that are also likely to be found to critically important in the years ahead. Additional analysis would be needed to more conclusively determine the relative importance of different incentive types.

Overall, total benefit from state incentives is linked with sales, but there are some outliers to this trend. For example, Washington ranks #1 in sales share, but its total level of benefits (#11) is not as high as some other states. On the other hand, Colorado tops the list in total benefits offered but is not seeing a such a high electric vehicle sales share (ranking #6). Louisiana also has high benefits (#4), but its sales share is lower than the national median. Four areas in particular may help explain why these states deviate from the trend: (a) year incentives were introduced, (b) demographic variables, (c) other incentives and actions not included in this analysis, and (d) automaker's electric vehicle deployment and marketing plans. Washington is one of the key areas of the EV Project (a public-private partnership installing home and public electric vehicle chargers in some areas of the country; EV Project, 2013), which could partially explain high electric vehicle sales in this state. Not only does the EV Project provide additional benefits to consumers, but it may help with consumer outreach and education about electric vehicles in general. Washington also has other incentives, some private or local, that were not included in this analysis. In Louisiana, demographic factors such as a relatively rural and politically conservative population could help explain its low electric vehicle sales share compared to the level of benefits offered. Colorado's incentives may not be as well known and established as some other states like California, which has been publicly supporting electric vehicles with strong outreach efforts for many years.

Georgia serves as an interesting case study because this state offers high incentives for BEVs (ranking #2), but its PHEV incentives are below the U.S. average. Georgia has an apparent strategy towards promoting BEVs and not PHEVs, and its sales share of BEVs versus PHEVs reflects this. Our regression analysis suggests that state-level incentives are more effective at driving sales of BEVs than PHEVs, so it is possible that even were Georgia to incentivize PHEVs as heavily as it does BEVs, it would not necessarily see comparable results. Still, we note that the potential for PHEVs to contribute to state and national goals of reductions in petroleum consumption and greenhouse gas emissions should not be ignored. PHEVs contribute greatly to total electric miles driven—for example, Chevrolet Volts passed the 1 million electric mile mark before Nissan LEAFs did (Voelcker, 2012a,b), and Volts also appear to be accruing similar electric-powered miles per month to LEAFs (INL, 2014).

In some cases state benefits for PHEVs depend on battery size, but the effect of this differential treatment appears to be small. In Colorado, Maryland, Pennsylvania, and South Carolina, Chevrolet Volts receive a larger subsidy than Prius Plug-ins, and in each of these states except Maryland, the majority of PHEV sales were Volts. For all other states and incentive types, PHEVs with different battery sizes are treated the same.

Lastly, we examine the ratio of consumer benefit-to-state-cost of the different types of incentives. We find that support for public charger installation offers the highest benefit

to BEV consumers compared to the amount of money it costs the state to implement. Direct subsidies and HOV lane access availability all have benefit-cost ratios around or slightly above 1. Comparing the benefit-cost ratios with the importance of each incentive in driving electric vehicle sales could potentially help states decide where government spending would be most effective in accelerating electric vehicle adoption. Subsidies, HOV lane access, and public charger installation for BEVs may offer the greatest effectiveness per dollar. Offering emissions testing exemptions for electric vehicles is particularly cost effective for the state, as this incentive typically does not require any government spending (and has minimal risk, as BEVs have zero and PHEVs low tailpipe emissions). However, we emphasize that caution should be taken in interpreting these results of the effectiveness of different incentives before additional research is conducted. This analysis only considered the benefits to consumers we were able to approximately monetize. The total benefit to society of promoting electric vehicles is much higher, as electric vehicles reduce negative externalities that are associated with conventional vehicles' impacts on local air pollution, contribution to climate change, and consumption of petroleum.

CONCLUSIONS

The focus of this study is to help inform on the extent and variation of U.S. state-level electric vehicle promotion policies and to analyze the impact of those policies on electric vehicle sales. The findings clearly indicate how states are offering a wide variety of incentives to accelerate electric vehicle adoption. We found a positive correlation between the total level of benefits from state-level incentives for battery electric vehicles and registrations of these vehicles, and we sought to further assess this relationship by comparing the effectiveness and benefit-cost ratio of different types of electric vehicle incentives. Three main conclusions are drawn from this study.

Conclusion 1: *State electric vehicle incentives are playing a significant early role in reducing the effective cost of ownership and driving electric vehicle sales.* Some of the states with the largest electric vehicle incentives—California, Georgia, Hawaii, Oregon, and Washington—have electric vehicle sales shares that are approximately 2–4 times the national average. The statistical regression findings reveal that the total monetary benefit to consumers from state incentives significantly positively correlates with BEV sales. These findings suggest that future state efforts to incentivize BEV sales through incentives that substantially drive down the total cost of owning and operating electric vehicles are likely to be effective.

Conclusion 2: *Some types of incentives appear to be more effective in driving electric vehicle sales than others.* Based on this novel quantification of many state-level policies, it appears that not all types of incentives affect BEV sales equally. A stepwise regression analysis shows that the most effective incentives are subsidies, carpool lane access, and emissions testing exemptions initiatives. In addition, a basic benefit-to-cost analysis that compares an incentive's benefit to consumers to state spending shows that public charger availability is an especially cost-effective incentive for BEV owners, and carpool lane access is cost effective for electric vehicle owners.

Conclusion 3: *Further research is needed to more deeply analyze the impact of other factors on electric vehicle sales.* As we show, some state governments offer a wide variety of incentives to electric vehicle consumers, while others have few or no incentives at all, and electric vehicle deployment ranges widely across states. In these early days of automakers introducing new electric vehicles and governments implementing electric vehicle promotion policies, there are still more unknowns than knowns. Many factors remain outside the scope of this state-level assessment. Examples of electric vehicle promotion actions that we did not include are those related to R&D programs, fleet-specific policy, vehicle regulations, low-carbon fuel policy, zero emission vehicle programs, as well as incentives offered by cities, utilities, workplaces, automakers, and insurance companies. Tracking how the level of automaker marketing activity or the limited geographic electric vehicle roll-out strategies play a role in connecting policy actions to market uptake of the new technology is also a key unexplored question. This study, a snapshot in 2013, does not include how technology costs could decline with battery innovation, greater mass-market economies of scale, second-life battery benefits, or other technical factors. Further study on these factors may help explain how some cities and states are more or less effective at accelerating electric vehicle adoption with a given suite of incentives in the future.

Based on the findings from this study it is clear that it is still early in the development of the market—and policies—for electric vehicles. Including both PHEVs and BEVs, the overall U.S. light-duty vehicle share of electric drive vehicles in 2013 was about 0.6%.

States like California, Georgia, and Hawaii that have greater electric vehicle promotion policies have approximately 3–4 times the national average electric vehicle share to show for it. On the other hand, other states offer incentives but have little electric vehicle market traction at this stage. Other states have relatively high electric vehicle shares but relatively few consumer policy benefits. This state-level analysis is but an early step to help inform the extent to which state actions, fiscal incentives and beyond, are helping to drive the early electric vehicle market, while economies of scale work to bring down the advanced technology costs. This work also alludes to how many other potential actions (e.g., by the federal government, cities, automakers, businesses) could also be critical in understanding the if, how, when, and where of electric vehicles' breakthrough to greater market shares.

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ANNEX A. REFERENCES FOR REVIEW OF STATE ELECTRIC VEHICLE INCENTIVES

A.1. SOURCE OF INFORMATION FOR INCENTIVES BY STATE

	Subsidies	License tax/fee	Annual fee	EVSE Financing	HOV	Parking	EMISSIONS TESTING EXEMPTION
Federal	IRS (2014)			State Government of Connecticut (2013)			
Alabama	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Alaska	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Arizona	AFDC (2014), State Government of Arizona (2014a,b, &c), Arizona Department of Revenue (DOR)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), Arizona Department of Transportation (2013)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Arkansas	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
California	AFDC (2014), Center for Sustainable Energy (2014), California Environmental Protection Agency (EPA) (2012)	AFDC (2014)	AFDC (2014)	AFDC (2014), California Energy Commission (2013), ClipperCreek (2014)	AFDC (2014), California Air Resources Board (2014), California Department of Transportation (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Colorado	AFDC (2014), Colorado DOR (2014), State Government of Colorado (2013)	AFDC (2014)	AFDC (2014), U.S. Department of Energy(DOE) (2013), State Government of Colorado (2013)	AFDC (2014), Clean Air Fleets (2013), Regional Air Quality Council (2013), Refuel Colorado (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Connecticut	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Delaware	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
DC	AFDC (2014), DC Department of Motor Vehicles (DMV) (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Florida	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), Florida Department of Highway Safety and Motor Vehicles (2014), U.S. Department of Transportation Federal Highway Administration (2013)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Georgia	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), Georgia DOR (2014), Georgia Department of Public Safety (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)

STATE-LEVEL U.S. ELECTRIC-VEHICLE INCENTIVES

	Subsidies	License tax/fee	Annual fee	EVSE Financing	HOV	Parking	EMISSIONS TESTING EXEMPTION
Hawaii	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), Government of the County of Hawaii (2012), Chang, Wiegmann & Bilotto(2008)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Idaho	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Illinois	AFDC (2014), (Caitlyn Barnes, Illinois Department of Commerce & Economic Opportunity, personal correspondence), (Darwin Burkhart, Illinois EPA, personal correspondence)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Indiana	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Clean Air Car Check (2014)
Iowa	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Kansas	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Kentucky	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Louisiana	AFDC (2014), State Government of Louisiana (2014), Louisiana DOR (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Maine	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), DMV.com (2011)
Maryland	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), (Chris Rice, Maryland Energy Administration, personal correspondence)	AFDC (2014), Maryland Department of Transportation State Highway Administration (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Massachusetts	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), State Government of Massachusetts (2014)
Michigan	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Minnesota	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Mississippi	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Missouri	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Montana	AFDC (2014), (Garrett Martin, Montana Department of Environmental Quality, personal correspondence)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Nebraska	AFDC (2014)	AFDC (2014)	AFDC (2014), U.S. DOE (2013)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)

	Subsidies	License tax/fee	Annual fee	EVSE Financing	HOV	Parking	EMISSIONS TESTING EXEMPTION
Nevada	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Nevada DMV (2014)
New Hampshire	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
New Jersey	AFDC (2014), New Jersey Department of the Treasury (2014a,b)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
New Mexico	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), New Mexico Motor Vehicle Department (2014), Government of the City of Albuquerque (2014)
New York	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), New York Department of Transportation (2014), LeSage (2012)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
North Carolina	AFDC (2014)	AFDC (2014)	AFDC (2014), U.S. DOE (2013)	AFDC (2014), North Carolina State University (2013)	AFDC (2014), North Carolina Department of Transportation (2014), Google Map (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), North Carolina DMV (2014)
North Dakota	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Ohio	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), (Hannah Smith, Ohio Development Services Agency, personal correspondence)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), DMV.com (2013)
Oklahoma	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), Oklahoma Clean Cities (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Oregon	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Oregon Department of Environmental Quality (2014)
Pennsylvania	AFDC (2014), Pennsylvania Department of Environmental Protection (2013), Pennsylvania Department of Environmental Protection (2014a)	AFDC (2014)	AFDC (2014)	AFDC (2014), Carter (2012), Pennsylvania Department of Environmental Protection (2014b)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Warner (2011)
Rhode Island	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Rhode Island Emissions & Testing website (2014)
South Carolina	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
South Dakota	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)

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	Subsidies	License tax/fee	Annual fee	EVSE Financing	HOV	Parking	EMISSIONS TESTING EXEMPTION
Tennessee	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), Tennessee Department of Transportation (2013)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Texas	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Texas Department of Public Safety (2011)
Utah	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014), Utah Department of Transportation (2014), Chang, Wiegmann & Bilotto(2008)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Utah Motor Vehicle Division (2014)
Vermont	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Virginia	AFDC (2014)	AFDC (2014)	AFDC (2014), U.S. DOE (2013)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Virginia DMV (2014)
Washington	AFDC (2014), JUSTIA US Law (2013)	AFDC (2014)	AFDC (2014), U.S. DOE (2013)	AFDC (2014), Le (2013), Hartman (2013), (Patti Miller-Crowley, Washington State Department of Commerce, personal correspondence)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
West Virginia	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)
Wisconsin	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014), Wisconsin Department of Transportation (2013)
Wyoming	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	AFDC (2014)	DMV.ORG (2014), Wikipedia (2014)

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