



PRINCIPLES FOR EFFECTIVE ELECTRIC VEHICLE INCENTIVE DESIGN

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ACKNOWLEDGEMENTS

This work is conducted for the International Zero-Emission Vehicle Alliance and is supported by the ClimateWorks Foundation. Uwe Tietge provided critical input on an earlier version of the report. The authors thank participants of the International Zero-Emission Vehicle Alliance for their reviews of the work.

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EXECUTIVE SUMMARY

Many governments around the world, faced with declining air quality and their own climate goals, have been working to accelerate the market for electric vehicles. In order to spur the sale of electric vehicles, they have used regulation, incentives, public-private partnerships, outreach campaigns, and have improved charging infrastructure. Because the upfront costs of electric vehicles are currently higher than conventional cars, the policy instrument for promoting those sales that tends to get the most attention is the fiscal incentive. But the types of incentives used to entice prospective consumers vary widely.

This study looks at the emerging best practices in the design of the electric vehicle incentives. It investigates the design of electric vehicle fiscal incentives across major markets in North America, Europe, and Asia. Catalogued in the study are various aspects of electric vehicle incentives, including the magnitude, type (e.g., rebates, sales tax exemptions), the eligibility by technology type, the timing of the incentive, and the durability of the incentives. The analysis quantifies both what incentives are in place and the link between the incentives and electric vehicle uptake.

Figure ES-1 provides a summary of major electric vehicle markets that exemplify best practices in their electric vehicle incentive programs. Together, the ten markets represent over half of global electric vehicle sales in 2014, and they include the leading markets in terms of share of new vehicle sales that are electric. As shown in the figure, the incentives in these markets all tend to have common characteristics. The incentives are substantial for battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), available close to the point of sale, offered to leased vehicles, available for company vehicles, durably locked into place for at least several years, and relatively simple for consumers and dealers to understand their value.

Table ES-1. Summary of markets with electric vehicle incentive best practices

Market	Electric vehicle uptake		Incentive design principles							
	Sales	Share	Substantial BEV	Substantial PHEV	Upfront	Lease	Company	Private	Durable	Simple
	0 50,000	0% 10%								
California			X	X	/	X	X	X	X	X
Japan			X	X	/	X	X	X	X	/
Norway			X	X	X	X	X	X	X	/
Netherlands			X	X	/	X	X	/	/	/
United Kingdom			X	X	X	X	X	/	X	X
France			/	X	X	X	X	X	/	/
Beijing			X	/	X	X	X	X	/	X
Sweden			/	/	/	X	X	X	/	X
Washington			X	X	X	X	X	X	X	/
Denmark			X	X	X	X	/	X	/	/

NOTES: "X" denotes principle is generally met; "/" denotes principle partially met

Based on this report's findings, we determine that a set of best-practice principles is emerging regarding the design of electric vehicle incentives. Most electric vehicles globally are sold in markets with substantial incentives and, in particular, in markets where the incentive design embodies the best principles identified here. Various aspects about the incentives' design can affect factors like the total consumer value, the consumer's eligibility, the eligibility of electric vehicle models, and the understandability of the incentive to dealers and consumers alike.

Based on our analysis, we conclude by pointing out four principles that are emerging to define the optimal design of electric vehicle incentives:

Move incentives up front to the vehicle purchase and make their value visible to dealers and prospective consumers. A number of incentives have suffered because their value at the time of vehicle transaction is unclear to both the buyer and the seller. Making incentives available at the time of purchase, or shifting the incentives to vehicle purchasing tax exemptions or reductions of similar value, appear to be effective solutions.

Make the value of incentives crystal clear to consumers and dealers. Incentives that have complex indexing of the incentive magnitude—for example, to consumer income, engine size, vehicle emission rates, battery size, or comparable non-electric vehicles—compromise dealer communication and consumer understanding. Simpler incentive programs, which are publicly posted on government websites and distributed to all dealers, would help alleviate this issue.

Ensure the incentives are available to the full target market. Electric vehicles can be an attractive fit in many settings: for company and private cars, government and private company fleets, taxi and car-sharing services, and leases and purchases. When major customers or purchasing options are made ineligible for the incentives, it reduces the effect the incentives can have on driving sales and broadening the exposure of the new technology. Governments can work to remove eligibility constraints to expand the appeal and awareness of electric vehicles to a larger consumer market.

Commit to durable incentives that allow manufacturers, dealers, public outreach campaigns, and consumers to rely on them for at least several years. Prevailing uncertainty over whether incentive programs will be maintained is disruptive and undermines the efforts of industry and prospective consumers. Industry gains from the ability to plan their product placement and strategically market their incentives, and consumers need certainty to weigh their investment. Securing incentive programs for several years—ideally to 2020—is best suited to assist the larger market transition. Within such a framework, governments can still regularly review the incentive policies and, if needed, make adjustments.

The implications of this research on electric vehicle incentives are broad. Over 500,000 electric vehicles were sold globally in 2015, up from just hundreds in 2010. Most of these electric vehicles were sold in markets where well-designed fiscal incentives are in place. A key question is how quickly electric vehicles could move beyond this early higher-cost stage to larger volume, greater economies of scale, and lower costs. Until then, optimally designed incentives are bringing the effective cost of electric vehicles closer to those of conventional vehicles, helping to usher in the new electric-drive fleet more rapidly.

I. INTRODUCTION

Electric vehicles continue to gain traction in the marketplace. More electric vehicle models are sold in more markets, and electric vehicle sales globally continue to rise. As of September 2015, one million cumulative electric vehicles were sold globally. This one-million-vehicle milestone was achieved several years faster than for non-plug-in hybrid vehicles, despite the issues of plug-in vehicles related to higher cost, vehicle range, and charging infrastructure.

Figure 1 shows annual electric vehicle sales globally from 2009 through 2015, with a breakdown of the major markets (based on data from Pontes, 2016a). As shown, the increase in electric vehicle sales has mostly been in North America, Europe, and Asia. The United States represents about 33%, Europe 31%, China 22%, and Japan 10% of the 1.2 million plug-in vehicles sold through 2015. The total annual electric vehicle sales surpassed milestones of 200,000 in 2013, 300,000 in 2014, and 500,000 in 2015. In 2015, annual sales in China increased the most, tripling from 2014. Sales in the European markets of Denmark, France, Germany, the Netherlands, Norway, Sweden, and the United Kingdom approximately doubled from 2014 to 2015.

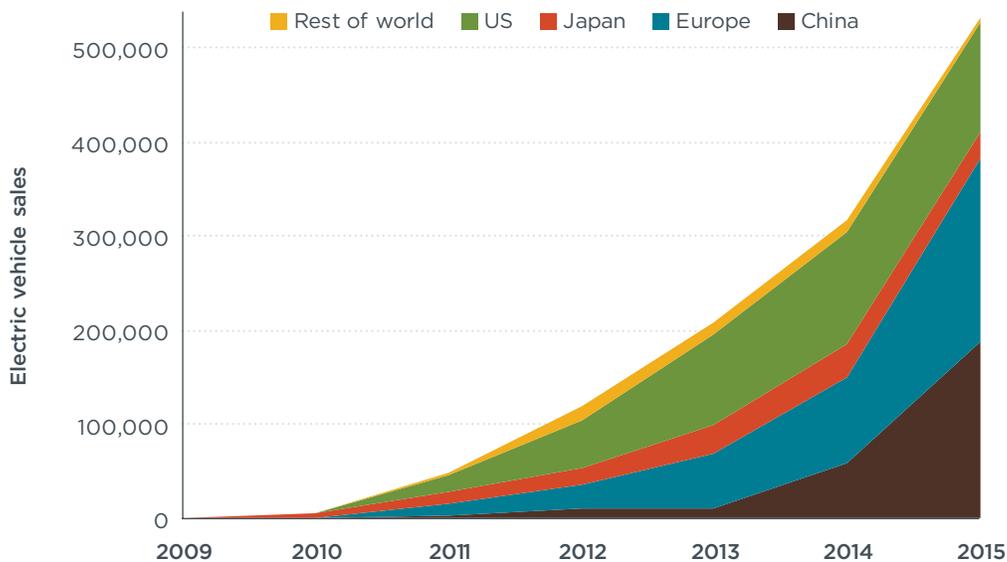


Figure 1. Annual electric vehicle sales globally through 2015

One important aspect of the early electric vehicle market development has been direct support from major governments around the world. It is widely expected that electric vehicle costs will reduce over time, and that until then a combination of supporting incentives and policy will be key in accelerating the early market development (NRC, 2013, 2015). Public subsidies and taxation reductions for electric vehicles in the leading markets are often substantial. Evidence to date indicates that there are major environmental, consumer fuel-saving, and economic benefits associated with electric vehicles that greatly exceed the costs of electric vehicle incentives (see, e.g., EPRI and NRDC, 2015a, 2015b; Greene et al., 2014; Nealer et al., 2015; Cambridge Econometrics, 2015; Roland-Holst, 2012). More broadly the incentives are motivated by the long-term

research, which indicates that electric vehicles will be critical for major economies to achieve their long-term climate goals (Lutsey, 2015c; Creutzig et al, 2015).

As a result, governments throughout North America, Europe, and Asia have spurred market growth through a combination of financial incentives, other incentives such as parking and lane access, charging infrastructure, and education and outreach activities (Lutsey, 2015b). Incentives can make up a significant portion of the total vehicle cost, especially in places like Norway and the Netherlands, for example (see OECD, 2015; Mock and Yang, 2014).

Many government actions are key to support early electric vehicle market growth, but generally financial incentives have drawn the most attention. Financial incentives tend to be a major focus because the higher initial cost of electric vehicles relative to conventional vehicles is routinely mentioned as a foremost market barrier. Incentives are also a focal point in electric vehicle policy discussions because they are related to key questions about what drives vehicle consumer behavior, about the value of supporting electric vehicles as an industrial policy, about the cost-effectiveness of supporting electric vehicles for their environmental benefits, and about competing uses of government spending.

Incentives are found to be a statistically significant driver for increased electric vehicle sales in different technical studies by various research groups (see e.g., Jin et al, 2014; Lutsey et al, 2015; Sierzchula et al, 2014; Li et al, 2016; Narassimhan and Johnson, 2014). In the United States and Europe, leading electric vehicle markets such as California, Norway, and the Netherlands tend to have the largest financial incentives, along with many additional policies (Lutsey, 2015b). Leading electric vehicle markets that previously had substantial incentives, but then had them repealed, have seen major drops in sales. For example, the U.S. state of Georgia in the United States was a leading electric vehicle market that then saw sales drop by over 80% after repealing its state-level tax credit (Badertscher, 2015). Also, the Netherlands reduced its electric vehicle incentives, and its electric vehicle sales share dropped in 2015 before increasing again in 2016 (Yang, 2014, 2016).

However, the same analyses demonstrate several counterexamples, where electric vehicle market response does not appear to be linked with financial incentives. For example, markets like Colorado, France, Illinois, Japan, and South Korea have had substantial incentives that have not been associated with a comparatively high electric vehicle uptake in 2014 and 2015. The potential underlying reasons for these incentive-rich markets not seeing electric vehicle uptake are many. For example, consumer awareness about the incentives (Krause et al, 2014), charging infrastructure (Li et al, 2016), and other non-financial local incentives (Bakker and Trip, 2014; Lutsey et al, 2015) are among the important other factors that affect electric vehicle uptake. The National Research Council (NRC) (2015) concluded that although the incentives are motivating prospective consumers, local incentives that differ in value, restrictions, and calculation methods are making it challenging to educate consumers on what is available.

The design of electric vehicle incentives may be one of the keys to ensuring incentives are helping to spur the early electric market. Various studies have pointed out a number of factors that may affect prospective electric vehicle customers, such as barriers in understanding the technology, awareness about the existence of incentives, and the engagement of electric vehicle dealers. For example, a preliminary analysis of U.S. state

incentives by Clinton et al (2015) indicated that the relative impact of incentive type (e.g., rebate, credit, tax exemption) is not yet clear. Elements of the incentive design affect the total consumer value, the eligibility for prospective consumers, the eligibility of electric vehicle models, and the understandability of the incentive to dealers and consumers alike.

This study takes an original, detailed, and global look at how electric vehicle incentives are being implemented. The study investigates the finer electric vehicle incentive design details of various incentives to better understand how the financial instrument, vehicle and ownership eligibility factors, and other details of the incentives may be having an effect on the electric vehicle market response. We first examine the research literature on how incentive types help address various vehicle consumer barriers. Then, we catalogue and analyze the existing electric vehicle incentives that are in use around the world. The scope of the assessment includes major national and regional consumer incentives across Canada, China, Europe, Japan, and the United States. As part of this assessment, detailed data on state and local electric vehicle incentives and electric vehicle uptake are also analyzed. In particular, a number of provinces (e.g., British Columbia), states (e.g., California), and cities (e.g., Beijing) with substantial financial incentives that add to national incentive policies are included.

The analysis is focused on cataloguing and analyzing how upfront costs (i.e., retail price plus registration taxes) costs of electric vehicles are affected by incentives in various markets. This analysis is focused on electric vehicle sales and incentives for 2014, but we note that incentives and their design have changed in 2015 and early 2016. Another commonly used metric to assess price differences between electric and conventional vehicles is total cost of ownership. For example, such analyses more comprehensively capture direct and indirect electric vehicle benefits associated with fuel and electricity rates, net fuel savings, maintenance costs, and other policy effects (e.g., see CARB, 2016; Lutsey, 2015a). Although there are broader consumer fuel-saving, environmental, and economic benefits that greatly exceed the incentives for electric vehicles, as mentioned above, this study is focused simply on the optimal design of the consumer purchasing incentives for electric vehicles.

In cataloguing the incentives, we collect tax and rebate policy information on the underlying incentive type vehicle technology eligibility (e.g., plug-in hybrids, by range), vehicle ownership type (purchase vs. leasing, company vs. private), duration, and other factors that are in play in major electric vehicle markets. The various incentives' value to consumers is quantified to provide global comparisons. Finally, links between the various incentives and electric vehicle uptake in the markets are discussed. The paper concludes with a discussion on what appears to be emerging as best practices for incentives to respond to various electric vehicle consumer barriers.

II. REVIEW OF LITERATURE ON ELECTRIC VEHICLE INCENTIVE DESIGN

A wide array of incentives and promotion actions exist that governments can adopt to promote electric vehicles. Before assessing the design elements of electric vehicle incentives in place around the world, we first consulted the research literature on which elements of incentives appear to be most effective in the deployment of electric vehicles.

Different governments emphasize a diverse set of goals in their electric vehicle development efforts, including greenhouse gas emissions, local air quality emissions, fuel savings, and industrial leadership. As a result, the “effectiveness” of electric vehicle incentives can be considered in multiple ways, such as ability to affect electric vehicle uptake, or weighing the costs versus the greenhouse gas emission abatement, air quality improvements, and reduction of fuel consumption. The literature on electric vehicles indicates widespread emissions and energy use benefits (see, e.g., Nealer et al, 2015; EPRI and NRDC, 2015a, 2015b). Electric vehicle rollout over the longer term appears to be the major desired effect of all the government policies on electric vehicles, as the potential long-term impacts in reducing emissions are considerable and likely critical for meeting climate goals for the transportation sector (Lutsey, 2015a). Greene, et al. (2014) indicate that the long-term benefits in the 2050 time frame from electric vehicles greatly outweigh sustained subsidies in the 2015-2025 time frame many times over.

Noting the widespread benefits of electric vehicles, this research strictly looks at effectiveness as the ability to incentivize more deployment, purchasing, and leasing of electric vehicles in the early development of the electric vehicle market for largely first-generation technologies. This section examines what the research literature indicates regarding how the type, timing, and clarity of incentives, as well as the eligibility of the incentives to various vehicle technologies and ownership types, can impact the efficacy of the electric vehicle incentive programs.

TYPE, TIMING, AND THE UNCERTAINTY OF CONSUMER INCENTIVES

Table 1 summarizes the four basic electric vehicle incentive types, and describes typical elements about how the incentives work, the approximate timing at which the consumer receives the benefit, and mentions several examples. As shown, there are four major electric vehicle incentive types: income tax credit, vehicle purchase rebate, one-time vehicle tax reduction, and annual vehicle tax reduction. Generally, depending on how each government implements the incentive, the type of the incentive has direct implications for the timing that the consumer receives the incentive. For example, many one-time vehicle tax reductions are at the point of vehicle sales, while rebates tend to be given within several months, and income tax credits tend to be given the year after the purchase, when households file taxes. The actual taxation details are far more complex, and greater details on incentive programs are described below. This general categorization is meant to help structure the assessment below on existing electric vehicle incentive programs.

Table 1. General electric vehicle incentive types and their timing

Category	Type	Consumer value	Typical timing	EXAMPLES
Subsidy	Income tax credit	A reduction of annual consumer taxes, for example from \$2,500-\$7,500 per vehicle, that would otherwise be paid (when there is tax liability)	End of tax year	U.S.
	Vehicle purchase rebate	A check, typically \$1,000-\$5,000 per vehicle, provided by government to vehicle consumer within a set amount of time	Within several months of vehicle transaction	California, Québec, France
Tax reduction	One-time vehicle tax reduction	A reduction in vehicle-related taxes, ranging from 5% up to 80% of the original vehicle retail price	Around time of vehicle purchase	Norway, Washington
	Annual vehicle tax reduction	A reduction in vehicle-related taxes, generally ranging from \$100 to \$500 per vehicle per year	Once per year	Germany

Research reveals that the timing of the electric vehicle incentive is a key factor in its effectiveness. Numerous studies indicate that incentives reducing the point-of-sale purchase price of an electric vehicle (e.g., immediate rebates or one-time vehicle tax reductions) are more attractive to consumers than incentives received at some future time (e.g., income tax credits or annual vehicle tax reductions) (see NRC, 2015; Gallagher and Muehlegger, 2011; Sierzchula et al., 2013). The type and timing of the incentive also affects the electric vehicle dealers’ ability to communicate, market, and sell electric vehicles to consumers. Point-of-sale incentives are considerably more valuable for dealers who are attempting to make the sale, as it eliminates the uncertainty of the incentive and its exact value (to dealers and consumers) and consumers’ discounting of its value; one dealer indicated that \$1,500 at point of sale would be more valuable than California’s existing \$2,500 rebate (Cahill et al, 2014; Cahill, 2015). However, whether point-of-sale incentives are more efficient uses of limited resources is an open question. Point-of-sale incentives apply directly to all eligible vehicles, while rebates are only provided if applied for by the consumer. In California, for example, about 70% of electric vehicle purchases receive rebates.

Researchers have identified many reasons why offering consumer incentives at the point-of-sale can be so important (see, e.g., NRC, 2015; Sierzchula et al., 2013; Gallagher et al., 2011; DeShazo et al., 2014). The reasons relate to the availability of capital, uncertainty about the future, and discounting of future benefits. A lower purchase price fundamentally reduces the amount of upfront liquid assets required from the buyer. An immediate vehicle tax reduction avoids the additional consumer effort and foresight about their end-of-year tax liability and ensures more potential customers are eligible. For example, to earn the full \$7,500 U.S. federal income tax credit, an individual tax filer would have to earn at least \$54,600 per year (Gordon et al., 2012). Upfront vehicle tax reductions can also eliminate uncertainty about the value of the incentive. Finally, consumers often highly discount future savings in their vehicle purchase decision, effectively reducing the perceived value of purchase incentives that are received at some future time (e.g., see Gallagher and Muehlegger, 2011).

To put consumers' implicit time valuation in context, Figure 2 provides an illustrative quantification of the reduced value of an electric vehicle incentive that, on face value, appears to be about a \$2,000 benefit, for various incentive types. The figure summarizes the estimated consumer value of various electric vehicle policy instruments that could be, on face value, seen as \$2,000 per vehicle purchase incentives. From left to right are an immediate sales tax exemption or rebate at the electric vehicle point of sale, a "quick" rebate received three months after purchase, an income tax credit received six months after purchase for a median-income household with insufficient tax liability, an annual circulation tax or fee exemption of \$400 per year for five years, and an annual circulation tax or fee exemption of \$200 per year for 10 years. As shown, the consumer value of incentives varies greatly, from as much as \$2,000 at the point of sale, down to about \$650 for a tax credit for a household with median income and insufficient tax liability. An implied consumer discount rate of 20% is assumed for future-year incentives, with error bars to represent a range from 10% to 40% discount rate (based on the Gallagher and Muehlegger, 2011, result of an approximate 13-42% discount rate).

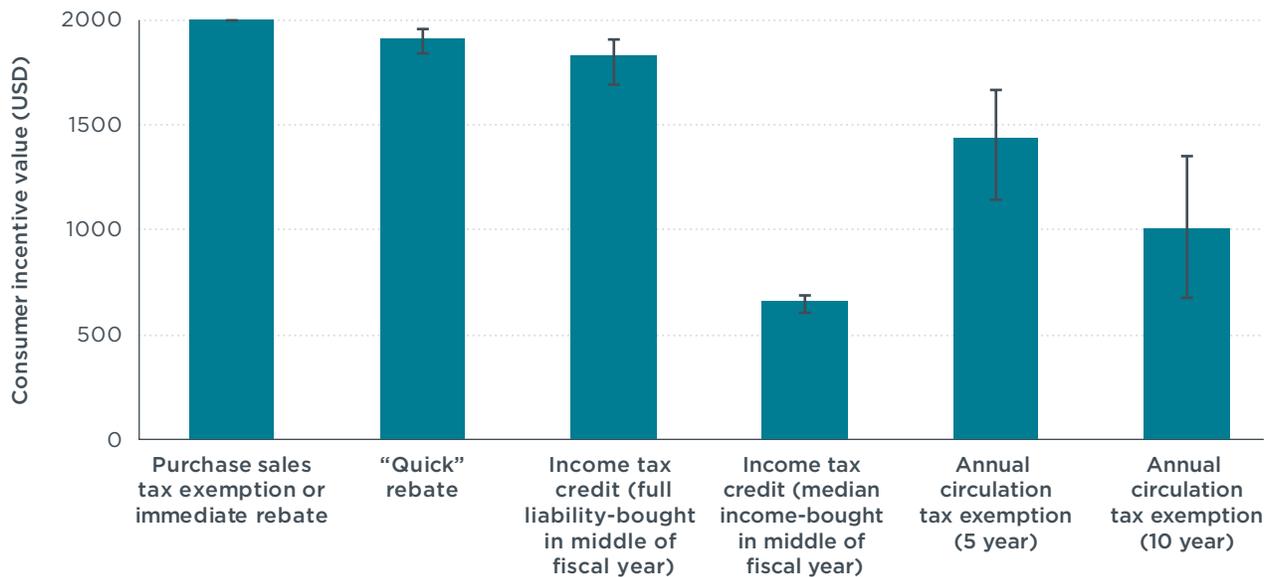


Figure 2. Illustrative consumer value of electric vehicle incentives that appear to be worth \$2,000 on face value in different policy instruments

Several of the above-mentioned analyses have also estimated how much more effective various incentive types are at generating consumer responses. One report on hybrid vehicles indicated that a \$1,000 sales tax exemption is associated with an increase in hybrid vehicle sales by 45%, whereas a \$1,000 income tax credit spurs hybrid vehicle sales by 3% (Gallagher and Muehlegger, 2011). Another analysis estimated consumer response according to different electric vehicle purchase incentive policy designs, finding that a \$1,000 purchase rebate leads to a 9.4% increase in BEV purchases, whereas a \$1,000 income tax credit leads to a 4.1% increase in BEV purchases (Narassimham and Johnson, 2014). These results suggest that rebates are more than twice as effective as tax credits in motivating consumers, and point-of-sale incentives can be an order of magnitude more effective.

INCENTIVE ELIGIBILITY BY OWNERSHIP TYPE

Another fundamental electric vehicle incentive design question is about its applicability for various vehicle ownership types. While many electric vehicle incentives are open to both purchasing and leasing electric vehicles, others are not. Similarly, some incentives are particularly established to spur vehicle purchasing (or leasing) by private individuals, by companies, or both. As described below, the research literature and automobile market trends suggest that restricted incentive applicability can negatively impact the relative effectiveness of the incentive.

Perhaps among the clearest lessons from the literature on the impact of various electric vehicle incentives is the importance of ensuring that leased electric vehicles are eligible for the incentives. The inclusion of leasing is important for several reasons. First, there has been a general shift from buying to leasing vehicles from 16% in 2009 up to 27% in 2014 in the United States (Kessler, 2015). The percent of new cars that are leased across Europe is generally much higher (KPMG, 2012), so any restriction on leased vehicles misses a significant fraction of the potential market. Moreover, leasing is especially attractive for electric vehicles to reduce risk and embrace the latest technology available. The electric vehicle leasing rate in the United States is significantly higher than the overall vehicle leasing rate: 86% of new Nissan Leaf drivers, 44% of Chevrolet Volt drivers, and 22% of conventional vehicle drivers leased based on a 2013-2014 survey (NRC, 2015). In addition, in situations where governments extend incentives to include electric vehicle leases, the consumer monthly payment is reduced, which effectively makes the consumer benefit of tax credits more immediate (rather than waiting until the end of the tax year).

Similarly, offering purchase incentives to both private consumers and company-owned electric vehicles ensures a greater share of potential drivers are eligible. Company-owned cars are especially popular in Europe, accounting for roughly half of all new car sales (Copenhagen Economics, 2010). Generally, corporations providing vehicles to employees claim the costs as business expenses and therefore pay a lower profit tax. Typically the vehicle is paid for by the company, and drivers are subject to a special company car tax. In the Netherlands for example, 25% of the company vehicle purchase price is considered part of a driver's taxable income; drivers of BEVs and PHEVs experience company tax reductions. Because of this exemption, the total value of incentives for many electric vehicle models in the Netherlands is greater for company cars than for privately owned cars (Mock and Yang, 2014). A similar situation has occurred in a number of other European countries, including France, Sweden, the United Kingdom and Norway. There are limited data on the differential shares of private and company cars that are electric, but offering comparable incentives for company and private cars enables higher electric vehicle incentive eligibility and higher electric vehicle uptake.

DURABILITY OF ELECTRIC VEHICLE INCENTIVE PROGRAMS

The literature review revealed another factor—the long-term durability of the program—as a key element in the optimal design of electric vehicle incentive programs. Beyond the policy effectiveness in spurring the market, there are many other factors that governments consider when designing their electric vehicle incentive programs. The electric vehicle incentive programs around the world have differing political, practical, and timeframe considerations. Some incentive programs, especially rebate programs, must be approved yearly as part of annual government budget legislation, so that at

any particular point in time, it is uncertain whether the rebate program will exist the following year. Other incentive programs are established for five (or more) years in advance, providing more certainty to vehicle manufacturers and consumers. Some governments have restrictions or more difficult procedures involved with changes to the tax code, and therefore generally adopt rebates (rather than point-of-sale tax reductions). As a result, such political and procedural factors can also have an impact on the programs' design and effectiveness.

Generally, sending longer-term signals to consumers, dealers, and manufacturers is advantageous, especially for advanced technologies like electric vehicles that will have a long-term transition. Cahill et al. (2014) emphasized the importance of this for automobile dealers, who expressed agreement on the need for continued government support. When assessing alternatives to the federal U.S. income tax credit, rebates would have required regular Congressional appropriations and would subject the program to more frequent review (CBO, 2012). Therefore, installing the long-term U.S. program for up to at least 200,000 vehicles per manufacturer (i.e., perhaps 6-10 years from the 2011 start date, depending on the company) provides long-term security to invest in the technology and to plan dealer and marketing programs accordingly. Similarly, the extension in 2013 of California's rebate program through 2023 greatly helped automobile manufacturers meet their goals in that state. Norway has also demonstrated long-term planning by securing incentives for a number of years; electric vehicle tax reductions were introduced in the 1990s and have recently been extended through the end of 2017 (Vergis et al., 2014).

III. DESIGN ELEMENTS OF EXISTING ELECTRIC VEHICLE INCENTIVES

Financial incentives for electric vehicles around the world aim to reduce electric vehicle costs at purchase and during ownership. This section catalogues and analyzes major national and regional consumer incentives across Canada, China, Europe, Japan, and the United States. The cataloguing of incentive elements includes a collection of tax and rebate policy information on the underlying incentive type (e.g., rebate, tax exemption), vehicle technology eligibility (e.g., plug-in hybrids, by range), vehicle ownership type (purchase vs. leasing, company vs. private), and duration of the incentive program. As the electric vehicle policies are highly dynamic and subject to changes within each calendar year, these summaries reflect the electric vehicle incentive policies that were in effect in September 2015.

The following sections break down several elements of the financial incentives and discuss specific practices across the various regions. Basic details of these incentives are summarized below; more detailed descriptions of the specific incentive designs are provided in Table 4 (for subsidies) and Table 5 (for vehicle tax reductions) in the Annex. We emphasize that, although we attempt to explain and quantify major details in the electric vehicle incentives, the fiscal policy mechanisms are generally more complex than presented here.

INCENTIVE TYPE

As introduced above (see Table 1), there are four major incentive types implemented around the world: income tax credit, vehicle purchase rebate, one-time vehicle tax reduction, and annual vehicle tax reduction. These electric vehicle incentives, as typically discussed by governments, generally fall into two broad categories: subsidies (including income tax credits and vehicle purchase rebates) and vehicle tax reductions (including the one-time vehicle tax reduction and annual vehicle tax reduction). Subsidies typically tend to be relatively transparent and direct, generally with a vehicle-specific dollar value attached. Vehicle tax reductions can be much more variable, opaque, and are dependent on both the tax system and typically the vehicle specs.

To subsidize vehicle purchases, many governments provide rebates that effectively reduce the purchase price for electric vehicles. The rebate is the most common type of electric vehicle purchase subsidy, with programs in the following regions: China central government, regions in China (e.g., Beijing, Shenzhen, Shanghai, Hefei, Hangzhou), Canadian provinces (British Columbia, Ontario, Québec), France, Japan, Korea, Sweden, many U.S. states (including California, Connecticut, Massachusetts, Washington), and the United Kingdom. France's Bonus-Malus feebate system provides a rebate for electric vehicle purchase (along with a system of fees for higher-emission vehicles). Less common is the income tax credit, provided by the U.S. federal government, which incentivizes electric vehicle purchases by reducing the amount of taxes owed.

Vehicle tax reductions are most commonly implemented at the national level and apply either on a one-time basis at the time of purchase, or annual taxes paid by consumers. Most regions in our analysis have chosen to fully exempt eligible electric vehicles from at least one type of one-time or annual tax. In addition, several countries like Germany, Japan, and Sweden offer reductions (i.e., but not full exemptions) in certain taxes for electric vehicles. The United States and Canada are the exceptions in this study in that

they do not provide vehicle tax or fee reductions at the federal level, although their federal tax level is relatively low compared to other regions. In some European countries, vehicles are commonly purchased as company vehicles for their employees; company-owned vehicles are eligible for tax reductions in countries such as France, Germany, the Netherlands, Norway, Sweden, and the United Kingdom.

INCENTIVE CONSUMER TIMING

Consumers receive incentives at different times depending on the policy design. Some incentives are directly deducted from the vehicle price at purchase. For example, China, Japan, and Québec all provide rebates at the point-of-sale. Similarly, vehicle tax reductions such as the one-time vehicle tax reduction generally take effect at the time of purchase, as is the case in France, the Netherlands, and Norway.

Some subsidies are provided within several months. For rebates in some regions (e.g., Massachusetts), electric vehicle buyers are obligated to submit rebate applications within several months of their purchase, and will then receive rebates shortly thereafter. Some regions, such as Québec, authorize or encourage dealerships to carry out the rebate process for consumers. In such situations, dealerships can collect the government rebates and pass along the incentive directly to consumers at the point-of-sale. The timing of income tax credits is slightly different, as the incentive is received at the end of the tax year when a household files taxes. This is unique to the United States, where the federal income tax credit is used to reduce the buyer's tax liability for that tax year. Depending on the time of year that the electric vehicle is purchased, a consumer may wait more than a year to realize the incentive. Annual vehicle tax reductions, such as those implemented in Germany and Denmark, often take many years for a consumer to receive the full benefit of the incentive.

INCENTIVE ELIGIBILITY

Governments can impose eligibility constraints that affect the applicability and the amount of incentive available to potential electric vehicle consumers. A number of regions have established various criteria and thresholds that electric vehicles must meet in order to receive the incentive. Several example threshold factors are summarized as follows. Governments can design incentive programs to promote a specific electric vehicle type; Beijing, for example, subsidizes BEVs but not PHEVs. Furthermore, jurisdictions can implement eligibility constraints based on electric vehicles' battery capacity. For example, Québec offers a rebate for PHEVs with battery capacity of at least 4 kilowatt-hours (kWh), with an increase in the PHEV rebate amount when the battery capacity reaches 7 kWh and 15 kWh thresholds (and also a flat rebate amount for all BEVs). The U.S. income tax credit applies only to vehicles with battery capacity of at least 5 kWh, and the amount of tax credit increases with vehicle battery capacity up to 16 kWh. There may also be eligibility constraints based on battery range. In order to receive available subsidies in China, for example, BEVs must have a range of at least 80 kilometers (km) and at least 50km for PHEVs. Governments may also offer varying levels of subsidies based on the vehicle's CO₂ emissions. Sweden, for example, subsidizes electric vehicles that emit no more than 50 gCO₂/km. Subsidies can also be dependent on consumer income. In California, consumers with an annual income greater than \$250,000 are ineligible to receive rebates (CARB, 2015). There are also other eligibility constraints for the various incentives. For example, California requires that consumers

who receive rebates retain the vehicle for at least 30 months to ensure emission-reduction benefits in the state.

Vehicle tax reduction policies also may have eligibility constraints that affect the amount of tax reduction allocated to consumers. Several example threshold factors are summarized here. Governments can design tax reduction policies to promote a specific electric vehicle type; for example, BEVs in Norway are fully exempt from vehicle taxes, whereas PHEVs receive partial vehicle tax reductions. There may also be eligibility constraints based on vehicle CO₂ emissions. Electric vehicles in the Netherlands, France, and the United Kingdom are exempt from vehicle taxes if their CO₂ emissions are below a certain level. The cost of an electric vehicle may be another factor that affects the amount of vehicle tax reduction available to a consumer. Washington State for example only provides vehicle tax reductions to electric vehicles that cost less than \$35,000. Vehicle tax reductions can also depend on vehicle curb weight; Denmark exempts taxes for electric vehicles that weigh less than 2000 kilograms (kg).

In addition to the above thresholds, there are other application guidelines and procedures that impact eligibility of various electric vehicles to receive incentives. For example, only electric vehicles that are listed in the official electric vehicle catalog can receive subsidies in China. For California and other U.S. states, only vehicles that meet the Zero Emission Vehicle program definitions are eligible.

In many regions, incentives not only apply to purchased vehicles, but also to leased vehicles. The financing company, or the car rental company, generally receives the full subsidy or vehicle tax reduction for new electric vehicles and then passes those savings to the lessee by lowering monthly, daily, or hourly payments. Leasing programs vary globally. In the United States, Canada, and Japan, consumers can lease the car over longer periods (usually 24 or 36 months) from a financing company with monthly payments. In China, leased vehicles refer to vehicles that are rented short term by a rental car company on hourly or daily basis. Regions where leased electric vehicles have been eligible for incentives include the United States (federal), Norway, the Netherlands, and China, whereas in several other cases they are not.

Similarly, incentives may also apply to both private and company-owned vehicles. Company-owned vehicles are common in Europe. Employers typically pay for these vehicles in full, and company-vehicle drivers therefore are required to pay a special company car tax. Drivers of company-owned electric vehicles are often eligible for some level of incentive that reduces this company vehicle tax. Regions that have offered significant vehicle tax reduction incentives to drivers of company-owned electric vehicles include Norway, the Netherlands, France, and Sweden, whereas Denmark has not.

INCENTIVE PROGRAM DURABILITY

There is usually an end date or a funding cap for the availability of subsidies when electric vehicle incentive programs are established. Some regions limit electric vehicle financial incentives to a certain timeframe. For example, in 2013, California secured incentives out to 2023, subject to annual appropriations. The United Kingdom has made funding available through 2020. Others have set a funding cap or limit incentives to a target number of electric vehicles. For example, Sweden plans to subsidize electric vehicles until the premium funds run out, whereas the United States will incentivize 200,000 qualifying electric vehicles per manufacturer. Incentive durability is important in allowing sustained automaker and dealer deployment promotion efforts, which are made more difficult if

incentives are unpredictable and unreliable. However, the pending expiration of incentives by established end dates can cause momentary spikes in electric vehicle sales.

In some cases, electric vehicle incentive programs are set up for a shorter term and renewed periodically depending on the program status and funding availability. This practice is more prevalent at the regional level. For example, in Massachusetts, over 90% of program funds were depleted in less than two years, and the government decided to approve another round of incentives as the funds were drawing down. In other cases, funds are exhausted or incentive programs expire without additional funding, such as the Canadian province of British Columbia, which allowed electric vehicle purchase incentives to expire in 2014—but then were reinstated about a year later.

Vehicle tax reduction incentives can also change over time. For example, the vehicle tax rates under the tax system in France and the Netherlands change annually, which impacts the magnitude of incentives each year. Vehicle tax reductions in the United Kingdom are subject to change every 1–2 years. Notably, the United Kingdom has redesigned their electric vehicle tax reduction incentives to only affect new cars, ensuring that those who purchased electric vehicles under previous tax rates retain those tax advantages. Norway initially planned to provide tax exemptions to the first 50,000 plug-in vehicles, but reached this target in April and the government decided to continue the program until 2017 (Autonews, 2015). Denmark has announced to gradually phase out tax breaks for electric vehicle by 2020 (Erb, 2015).

INCENTIVE LEVEL

Besides Sweden, which provides a flat subsidy amount to all vehicles that are eligible for electric vehicle subsidies, regions usually define one or multiple factors that determine the level of subsidy for each vehicle. The amount of subsidy is often based on electric vehicle category (i.e. BEV or PHEV), battery capacity, battery range, CO₂ emissions, income level, or some combination of these factors.

Figure 3 compares the subsidy level of some top-selling BEV models around the world. For conversion of different currencies, the report adopts currency exchange rates of the end of 2015. Generally regions provide the maximum subsidy across most or all available BEV models. In China and its cities, the BYD e6 and Tesla Model S are the only models eligible for the maximum subsidy due to their long battery range. For each model, the battery range is measured under the regulation of its major market. Japan is not included since the subsidy level is decided by the government and is based on the price difference between the electric vehicle models and its counterpart gasoline vehicle. To reiterate, Figures 3 and 4 below reflect the available subsidies that would be available for BEVs and PHEVs, respectively. Not all of these vehicles are available in all markets. Note that vehicles in the United States are eligible for both the U.S. federal incentive and applicable U.S. state incentives like those shown. For example, an electric vehicle in California would be eligible for the \$2,500 state rebate, and up to \$7,500 federal income tax credit.

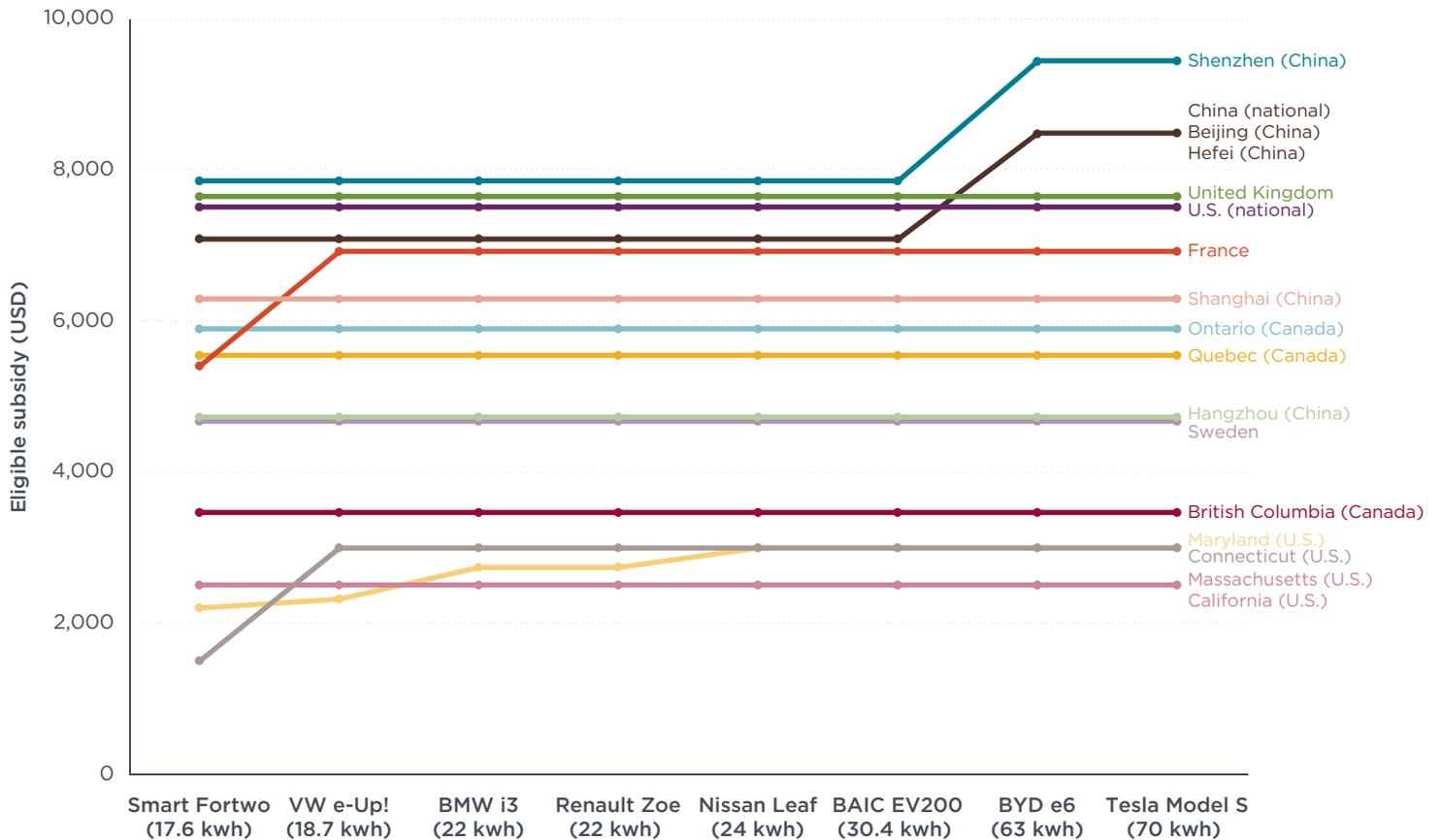


Figure 3. Available subsidies for battery electric vehicle models in major markets

Figure 4 compares the subsidy level of some top-selling PHEV models around the world. The subsidies for PHEVs are largely varied mostly because of differences in battery capacity. Models with lower battery capacity, such as Toyota Prius, are usually eligible for lower subsidy levels than the others. The Chevrolet Volt, a PHEV with the largest battery capacity, generally qualifies for the maximum PHEV subsidy. In several cases, the maximum subsidy available to PHEVs is similar in value to the minimum subsidy available to BEVs. The incentives shown are based on the specified vehicle attributes, but all of the models are not available for sale in all the markets.

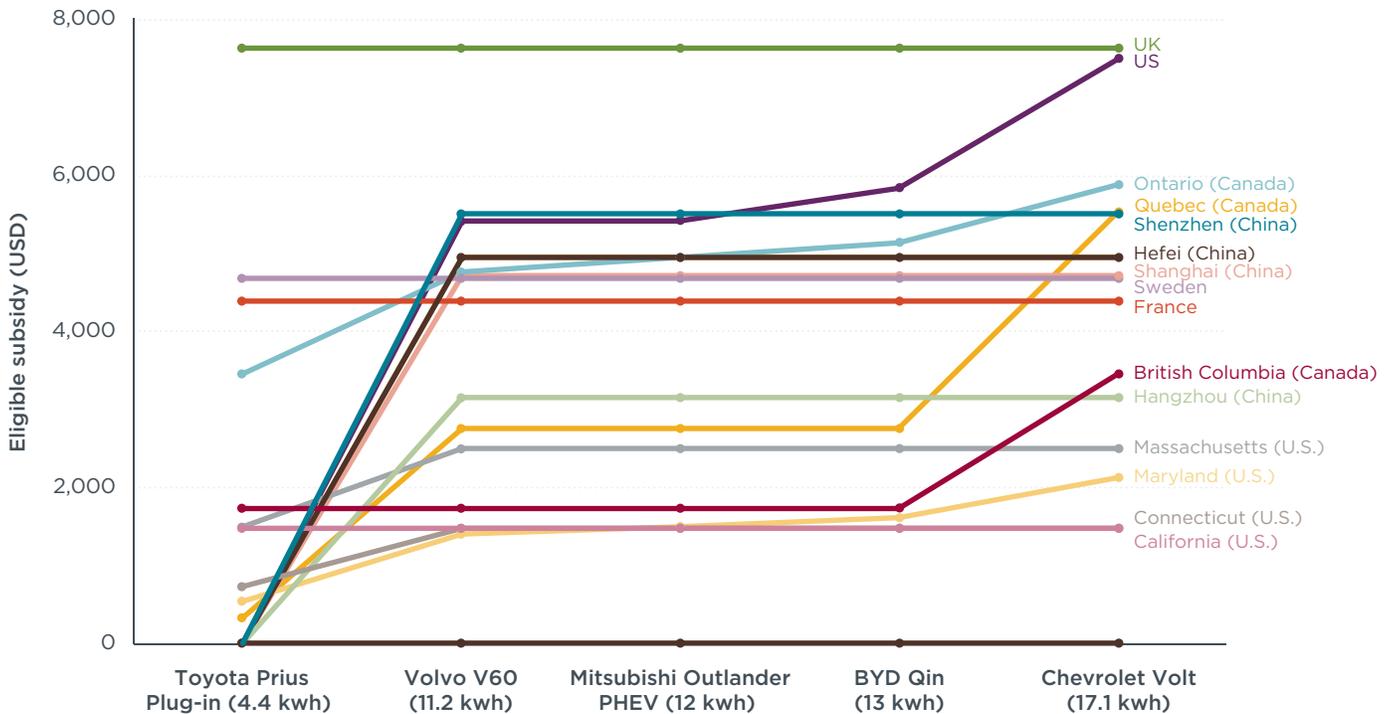


Figure 4. Available subsidies for plug-in hybrid electric vehicle models in major markets

In some cases, other factors such as a buyer’s income level or the price gap between an electric vehicle and its counterpart conventional vehicles also influence the subsidy level. Some governments offer increased incentive levels for lower-income buyers. In California, electric vehicle buyers with an annual income less than 300% of federal poverty limit will receive a higher rebate compared to others. Conversely, the U.S. federal incentive is a non-refundable income tax credit, and the actual value of the incentive that a prospective buyer can receive is limited to his or her tax liability for that tax year. In other words, if an individual owes less federal taxes than the eligible tax credit, the buyer will not receive the full tax benefit. In Japan, the level of electric vehicle subsidy is decided by the agencies based on the price gap between the electric vehicle and a specific counterpart conventional vehicle.

The level of incentives from vehicle tax reductions depends on the taxation system in each region. Under some tax systems (e.g., France and the United Kingdom) vehicle taxes are directly based on CO₂ emissions, and therefore the level of incentive for electric vehicles is determined by the CO₂ emission level from prescribed regulatory test procedures. Other governments tax vehicles differently. For example, many jurisdictions tax vehicles based on a variety of non-CO₂ vehicle-specific attributes, including vehicle weight, engine power, engine displacement, vehicle price, or some combination of these factors. Thus, the total value of incentives from vehicle tax reductions varies significantly due to differences in vehicle characteristics that determine the level of vehicle tax. Vehicle tax reductions in Norway, the Netherlands, and several China cities, for example, substantially reduce the purchase price of electric vehicles. Greater detail showing all the electric vehicle subsidies and tax reductions are provided in the annex below.

TOTAL INCENTIVE COMPARISON

To provide a more detailed examination of electric vehicle incentives across the regions, this section analyzes the total cost of the world’s highest-selling BEV and PHEV models (i.e., Nissan Leaf, Chevrolet Volt) and compares them with counterpart gasoline models (i.e., Nissan Sentra, Chevrolet Cruze). Although these electric vehicle models are not available for sale in every market around the world, they are shown in the figures as if they were available for sale in each jurisdiction analyzed in this study. Table 2 displays a number of key vehicle characteristics of the models selected for this assessment.

Table 2. Specifications of example models

Vehicle type	Nissan Leaf	Nissan Sentra	Chevrolet Volt	Chevrolet Cruze
	BEV	Gasoline	PHEV	Gasoline
Engine power [kW]	80	97	111	102.9
Cylinder capacity [cm ³]	—	1800	1400	1800
CO ₂ emission [g/km NEDC]	—	140.8	31	225.7
Weight [kg]	1477	1295	1607	1399
Footprint [m ²]	4.15	4.12	4.19	4.16
Battery range [km]	192.6	—	87.4	—
Battery capacity [kWh]	24.0	—	17.1	—
Manufacturer suggested retail price [USD]	29,010	16,480	26,670	16,170

Figure 5 compares the total cost of the Nissan Leaf (BEV) and Sentra (gasoline) across multiple markets that offer electric vehicle incentives. The total cost includes the manufacturer suggested retail price (MSRP) and applicable purchase and annual use taxes and registration fees over a 4-year period. The base price shown is simply the MSRP, excluding taxation, fees, and subsidies. The patterns of the turquoise bars indicate the type of BEV incentives provided by the region: subsidy (solid turquoise), vehicle tax reduction (hashed turquoise), or both subsidy and tax reduction (dotted turquoise). The brown bars represent the conventional Sentra’s MSRP and taxes in each region. In most regions, the total cost of the Leaf is lower than its base price, though to varying degrees, after the incentives are included. Sweden and Germany are exceptions where the BEV incentives are neither high enough to offset the high vehicle tax or reduce the BEV cost below that of the conventional vehicle. Despite the Leaf having a higher base price than the Sentra, government incentives have led to the BEV having lower overall cost than the conventional vehicle in the Chinese cities, Norway, Denmark, and the Netherlands. As shown in the figure, the China cities are where the Nissan Leaf BEV has the lowest absolute cost, as well as the largest positive cost differential versus the conventional Sentra.

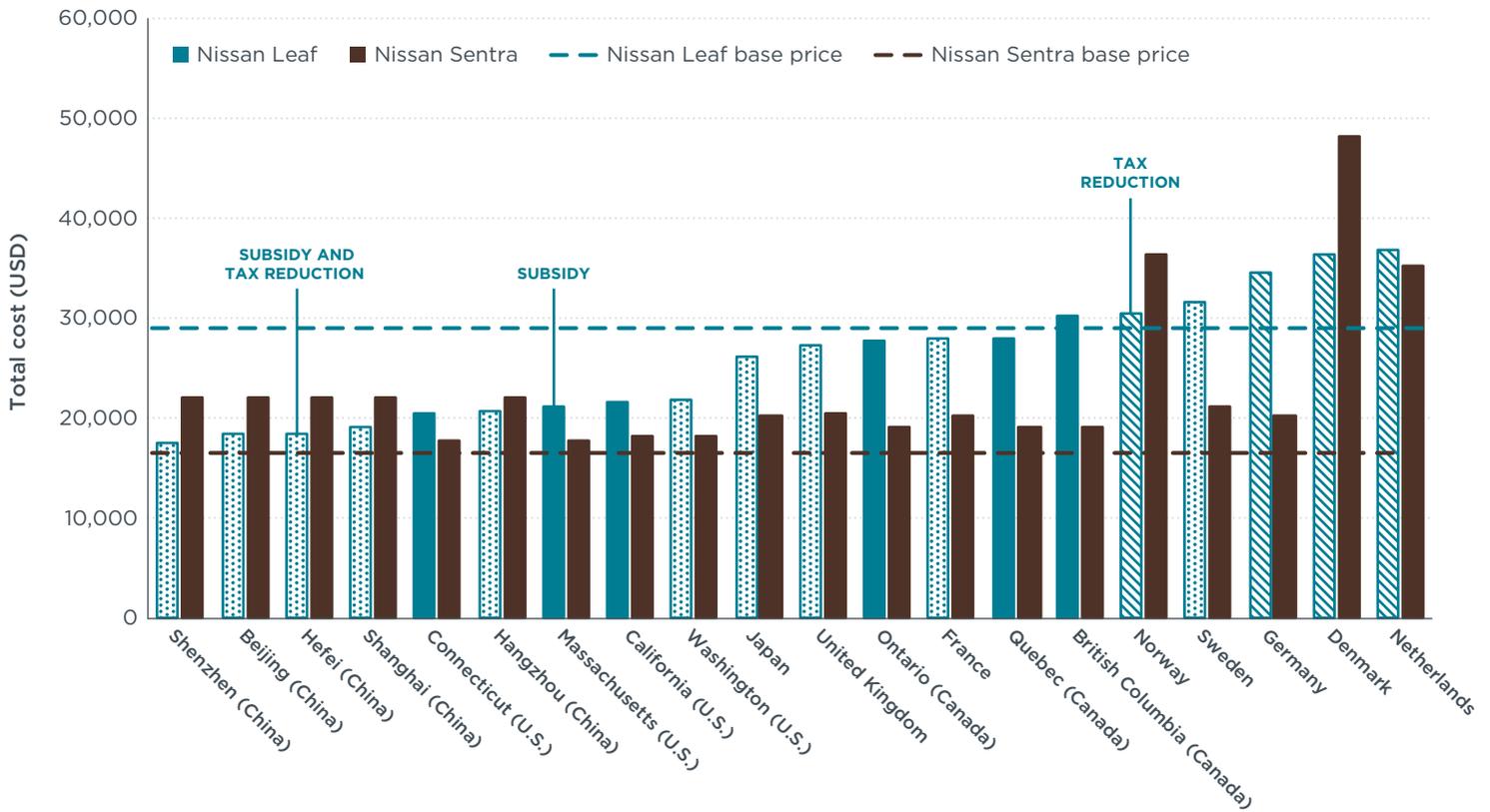


Figure 5. Estimated cost of the Nissan Leaf and Nissan Sentra across major markets, after including taxes, fees, and incentives

Figure 6 compares the total cost of the Chevrolet Volt (PHEV) and Cruze (gasoline). As above for BEVs, the total cost includes the manufacturer suggested retail price and applicable purchase and annual use taxes and registration fees. The patterns of the orange bars indicate the type of BEV incentives provided by the region: subsidy (solid orange), vehicle tax reduction (hashed orange), or both subsidy and tax reduction (dotted orange). The purple bars represent the conventional Cruze’s MSRP and taxes in each region. Similar to BEVs, incentives for PHEVs reduce the cost of the Volt below its base price in most regions, although the reduction is not as significant as for BEVs. Vehicle tax reductions appear to have the strongest impact on improving the Volt’s cost competitiveness, as demonstrated by the Netherlands, Denmark, and Norway. PHEV incentives also appear to be relatively strong in many Chinese cities, including Shenzhen, Hefei, Shanghai, and Hangzhou, where the combinations of subsidy and tax reduction contribute to a relatively lower cost of the Volt. In absolute terms, the Chevrolet Volt, after incentives, is the least expensive in various U.S. and China regions. In various other regions (e.g., Japan, Québec, Sweden, Germany), the PHEV Volt is at least \$4,000 more expensive than the gasoline Cruze, even after incentives are included.

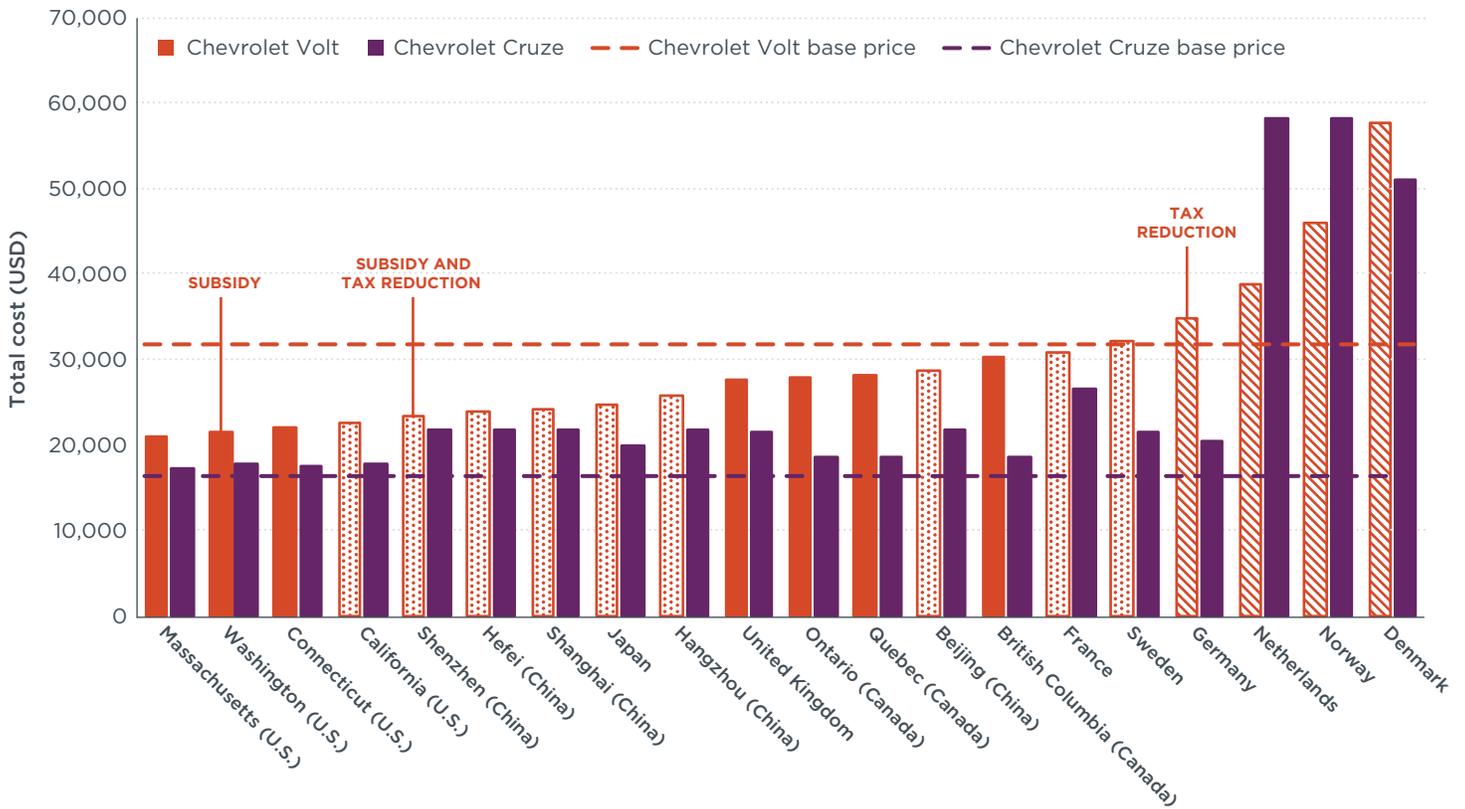


Figure 6. Estimated cost of the Chevrolet Volt and Chevrolet Cruze across major markets, after including taxes, fees, and incentives

Figure 7 provides a summary of the price difference between an electric vehicle and its comparable conventional vehicle in major markets, after including the vehicle price, taxes, fees, and incentives. The figure summarizes the results from the analysis in the figures above, presenting the Nissan Volt-Sentra BEV comparison and the Chevrolet Volt-Cruze PHEV comparison. The data is ordered from top, where electric vehicles are most advantageous, to the bottom, where electric vehicles are least advantageous compared to conventional vehicles. As shown there are seven markets (Norway, several cities in China, Denmark, and the Netherlands) where incentives make BEVs and PHEVs advantageous from a vehicle transaction, tax, and fee perspective, once incentives are included. In Beijing, BEVs have a cost advantage, but PHEVs do not. In several U.S. markets, including Maryland, Massachusetts, Connecticut, and California, incentives make electric vehicles have near cost parity with their conventional counterparts. To emphasize, this chart includes taxes, fees, and incentives, but *excludes* the fuel savings from the electric vehicles. It is notable that even though there are very substantial incentives in place in several of the markets (e.g., British Columbia, Sweden, Québec), the full cost, fees, and taxes still make the electric vehicles substantially more expensive, at about 35-50% more than their conventional comparable vehicle models.

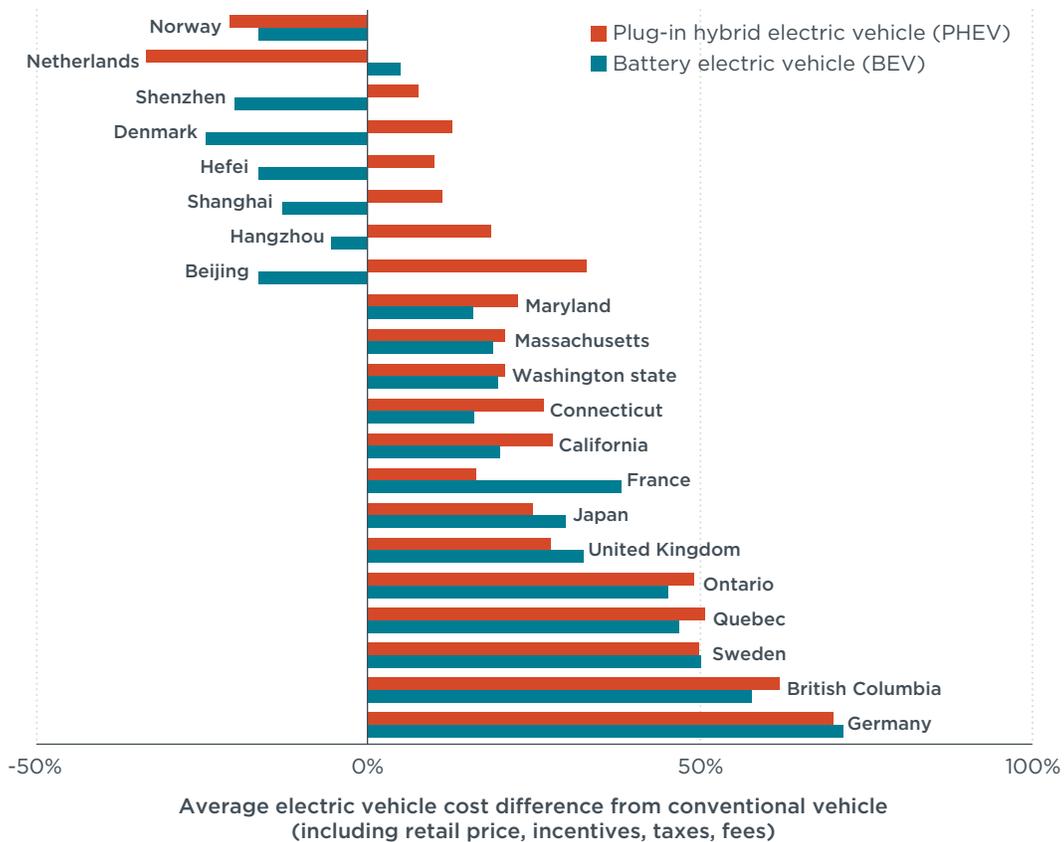


Figure 7. Electric vehicle price difference from comparable conventional vehicle in major markets, after including taxes, fees, incentives

To provide an additional summary comparison of the various incentives’ relative value to consumers, we sought to approximate the lost value for potential electric vehicle consumers due to various issues with the incentive design. The heterogeneous market of vehicle consumers responds differently to all the various factors. As a result, it is acknowledged that rigorous quantitative methods to precisely analyze the average lost incentive value from the incentive programs’ eligibility, type, timing, and other constraints described above are not available. Nonetheless, as a first-order approximation, several illustrative adjustments are made to discount the relative value of incentives in order to discuss the potential magnitude of what is at stake with these incentive design issues.

Figure 8 summarizes the electric vehicle incentives across the jurisdictions discussed in this study, and illustrates how the design of these incentives influences their effectiveness. The maximum face value of the incentive is shown for a Nissan Leaf (calculated as direct subsidies plus the difference in taxes for an electric vehicle compared to a conventional car, as above) is shown in the black markers. Design elements that detract from the value of the incentive to the consumer are shown in hatched colored bars, and the *effective* incentive value—the value to the average electric vehicle consumer—is shown in the brown bars. It is noted that this is an isolated analysis for discussion, but the follow-on analysis in Section IV does not include the incentive discounting.

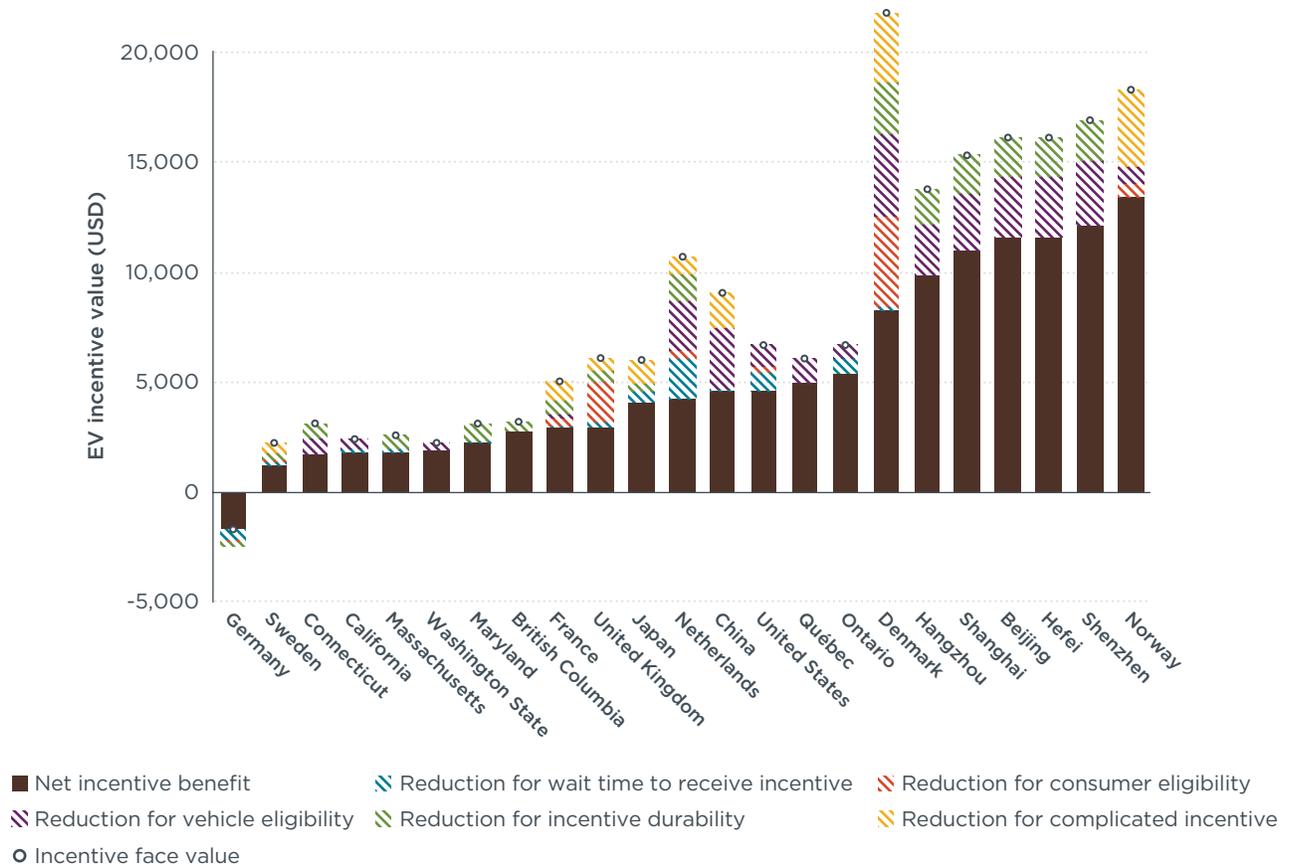


Figure 8. Electric vehicle incentive discounting and total effective consumer value

Figure 8 estimates the reduction in an incentives’ average consumer value due to how complicated the incentive is, incentive durability, limitations in incentive eligibility for certain types of vehicles and certain types of consumers, and the wait time before the value of an incentive is received. Each of these illustrative reductions in incentive value is calculated as follows. To discount how some of the incentive values are relatively “complicated,” we discount the incentive value by 10% if the incentive value is dependent on one variable such as CO₂ emissions or vehicle weight, and by 20% is applied if the incentive value depends on two or more such variables. To account for incentive durability, a reduction of up to 30% is made for incentives active for less than 5 years (from the introduction date of the incentive), with an additional reduction of up to 15% if the incentive is liable to change, for example with annual changes to the vehicle tax system. We note that electric vehicle sales have been shown to increase during a brief period before an incentive expires, but as this phenomenon does not affect the value of the incentive to consumers it so is not accounted for here.

Reductions in the relative electric vehicle incentive value are also approximated here for vehicle eligibility constraints, like vehicle technology type and ownership type. For example, the consumer eligibility factor accounts for the fraction of the total incentive value that is available only for companies or for private individuals, multiplied by the electric vehicle sales share for each consumer group. For this factor, an assumption of 33% company sales and 67% private sales was made for countries for which more specific data was not available. To calculate the reduction in incentive value for the wait

time to receive the incentive, we applied a 20% annual discount factor for incentives or portions of incentive packages where the incentive is not provided up front to the consumer. These reductions were multiplied by each other to estimate the effective incentive value to average prospective consumers in each jurisdiction.

As shown in Figure 8, some of the effective value of incentives in some jurisdictions is more affected by these incentive design elements than in others. For example, British Columbia provides a simple up-front rebate to electric vehicle purchases, for all types of electric vehicles and all types of consumers, in a program that is not liable to change every year. The effective value of the electric vehicle incentive in this province is thus almost as high as its face value. On the other hand, Denmark and the Netherlands have complicated tax incentives, some elements of which are provided years later in the form of an annual circulation tax exemption, are only provided to company or private purchases, apply differently to different types of vehicles, and are liable to change with changing tax rates every year. Overall, the effective value of every incentive we assessed is negatively impacted by the incentive's design, but this figure allows us to see approximately how certain jurisdictions have maximized the value of their electric vehicle incentive programs. Note that other figures and analysis in this report do not include these discounting factors.

IV. RELATIONSHIP BETWEEN INCENTIVE DESIGN AND UPTAKE RATES

Based on the two sections above on the research literature and the comparison of the various incentive characteristics, we examine the three major regions of the United States, Europe, and China to see how the incentives are linked to electric vehicle sales. In this section, data on incentive value and vehicle uptake are presented, then examples where incentives are linked with higher sales, as well as counter examples where incentives appear not to match sales, are discussed. These three short case studies provide additional depth in the United States (looking at electric vehicle sales shares at the metropolitan area level), European countries (examining incentives for two popular electric vehicle models and overall electric vehicle shares), and China’s electric vehicle pilot cities (including 2015 sales data).

U.S. STATE ELECTRIC VEHICLE INCENTIVES

The greatly varied electric vehicle incentive policy throughout U.S. states and cities provides many cases to compare and contrast the incentive design elements discussed above and identify which ones are linked with leading electric vehicle uptake. Figure 9 summarizes the average consumer incentives in several U.S. states that are analyzed above and others. The data are based on collections of data from previous research (Jin et al, 2014; Lutsey et al, 2015a) and updates in 2015. The figure shows the electric vehicle share (black line, left axis), and the available incentives (bar chart, right axis). As shown in the figure, there are seven leading states with electric vehicle uptake above 1% of new light-duty vehicle sales. Of those states, the top three states had substantial electric vehicle incentives. California had a \$1,500 to \$2,500 rebate per vehicle that allows leasing and is secured beyond 2020. Georgia’s \$5,000 rebate for BEVs was among the highest in the nation, but there were no corresponding PHEV incentives, and PHEV sales shares were below average. The Washington 2014 incentive shown is the only point-of-sale tax exemption in the United States. Note that several of U.S. incentives have changed throughout 2015. For example, the Georgia incentives were suspended.

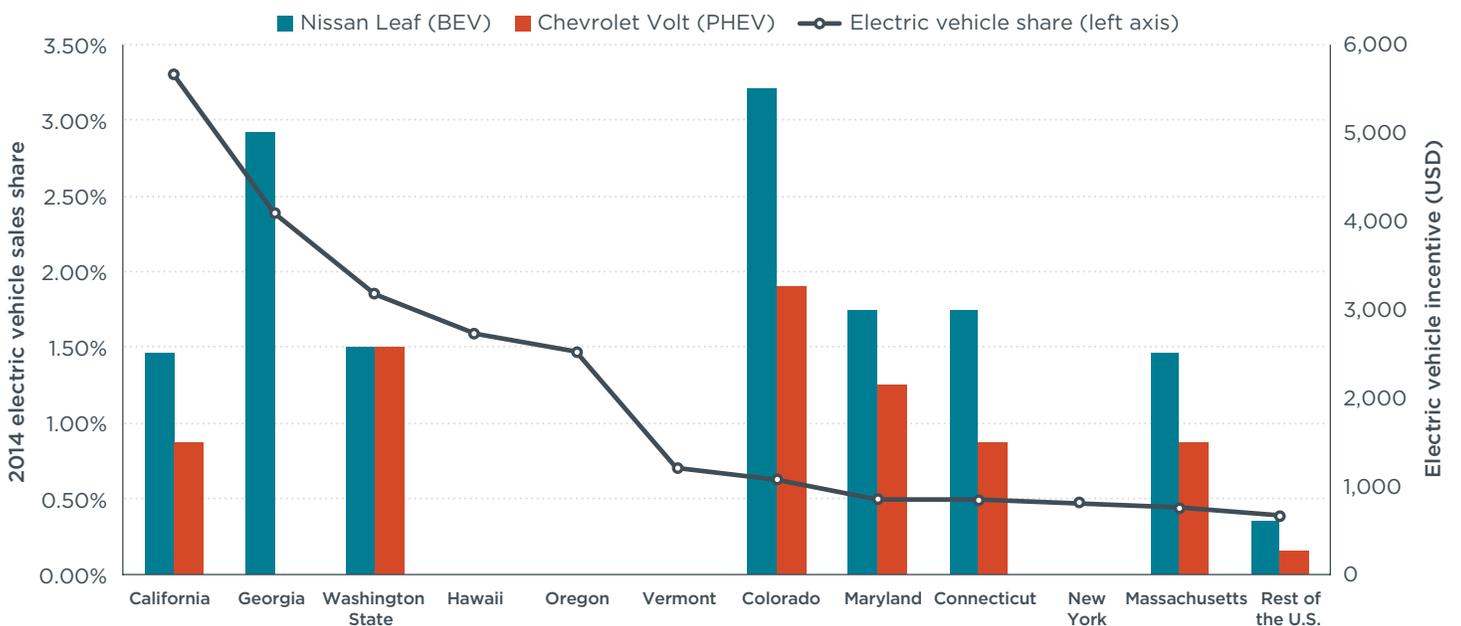


Figure 9. Electric vehicle incentives and 2014 shares of new vehicles in selected U.S. states

There are examples in Figure 9, as well as in other U.S. states, where significant consumer incentives have been in place with average or below-average electric vehicle uptake. In each case, there appears to be a restriction within the incentive design identified above that is partially connected with the relative ineffectiveness of the programs. For example, Colorado has one of the most attractive incentives, but the complex indexing of the subsidy to income and battery size has likely confused consumers and prevented clear dealer communication about its value. Incentives were available in Texas, but their impact may have been muted due to the incentives not being reliable or well known, and due to the program's limited availability throughout the year. A Pennsylvania incentive program was similarly limited, being offered for up to only 250 electric vehicles, with leased vehicles ineligible. The Connecticut, Massachusetts, and Maryland cases involve newer state rebate programs and therefore warrant further examination with 2015 data. More broadly, extensive analysis of U.S. city, state, utility, and other actions revealed that, while incentives are linked to electric vehicle uptake, so too are charging infrastructure, non-financial incentives, and other consumer outreach activities (Lutsey et al., 2015).

EUROPE'S ELECTRIC VEHICLE INCENTIVES

Like U.S. states, European nations vary greatly in their electric vehicle incentives and uptake. This section provides a summary of the estimated total value of incentives and electric vehicle sales share for seven European nations. Estimates include an evaluation of direct electric vehicle purchasing rebates as well as information on national taxation policies in order to quantify the tax difference between electric vehicles and their non-electric counterparts, using the same method as above and as applied previously (Mock and Yang, 2014). The estimated total values of incentives are calculated for the Nissan Leaf BEV and Mitsubishi Outlander PHEV—two of the highest-selling electric vehicle models in Europe in 2014-2015—as well as the Chevrolet Volt PHEV.

Figure 10 shows the estimated total value of incentives and electric vehicle sales share for seven European nations. These are the highest electric vehicle-selling countries in Europe and represent about three-quarters of European electric vehicles sold in 2015. Similar to other research (e.g., Mock and Yang, 2014; Thiel et al., 2015), we find that in general the electric vehicle market shares align with the value of financial incentives that are available in each nation. Electric vehicle uptake seen in the Netherlands and Norway supports this assertion. The Netherlands offers significant purchase tax exemptions and allows leased and company-owned electric vehicles to be eligible for incentives. Norway provides substantial point-of-sale tax exemptions, however incentives are generally much larger for BEVs than for PHEVs, and BEVs have dominated the electric vehicle market as a result.

As mentioned above, vehicle tax reduction incentives are calculated based on the differences in taxes between an electric and non-electric counterpart vehicle. In Norway, the amount of taxes on the Mitsubishi Outlander PHEV is slightly greater than the amount of taxes placed on the petroleum Outlander model, resulting in a slight disincentive (see Figure 9). Contrarily, the amount of taxes on the Chevrolet Volt PHEV is substantially less than on the counterpart Chevrolet Cruze (largely due to major differences in CO₂ emissions, see Table 2), resulting in a significant incentive. The difference in value between the Outlander and Volt PHEVs demonstrates how significantly incentives can differ even among the same electric vehicle category. Incentives in Norway are available to leased and company-owned electric vehicles.

Vehicle tax rates in Norway and the Netherlands are substantially higher than those in other markets, making the value of vehicle tax reduction incentives in both countries generally higher. Minimizing eligibility constraints and providing significant fiscal incentives have spurred market growth and electric vehicle shares have soared to approximately 3.5% in the Netherlands and 14% in Norway.

Sweden has the third highest electric vehicle sales share of approximately 1.5%. In Sweden, vehicles with CO₂ emissions less than 50 g/km are eligible for a “super green car premium” subsidy valuing up to SEK 40,000 (i.e., over USD\$4,500) that is provided after application approval and includes leasing and company-owned vehicles. However, electric vehicle uptake in Sweden may have suffered from the program’s lack of reliability, as it was designed to provide subsidies to only the first 5,000 qualifying vehicles. The limit was reached in 2014, and months later, the government approved reinstating the program for another 5,000 vehicles (Swedish Energy Agency, 2015). France and the United Kingdom both offer relatively strong electric vehicle purchase incentives that are received at the electric vehicle point of sale, and the programs include leased and company-owned vehicles. It is also noted that the most recent data is indicating that electric vehicle uptake in most European markets for 2015 is about double the volumes in 2014 (See Pontes, 2016b).

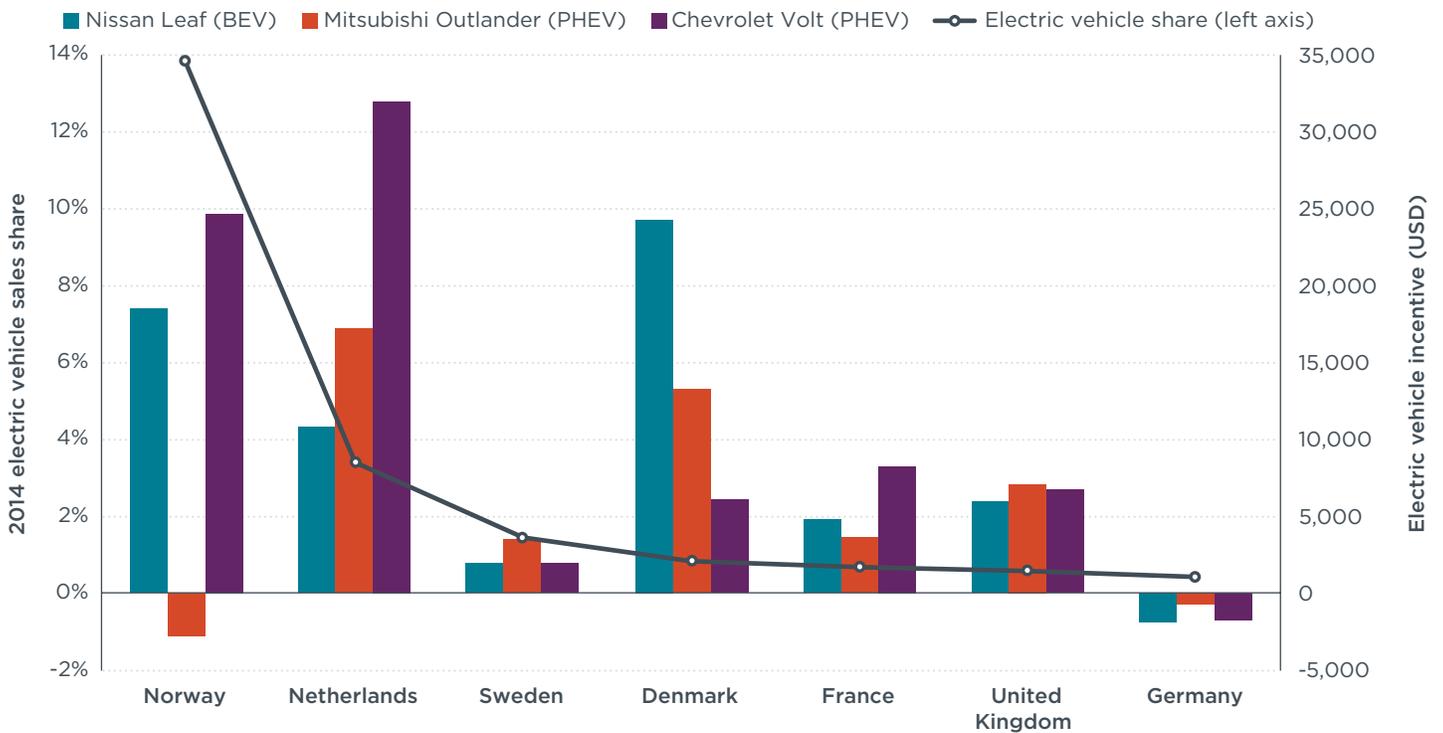


Figure 10. Electric vehicle incentives and 2014 share of new vehicles in selected European countries

Denmark provides an interesting counterpoint to the electric vehicle incentive-sales link. Denmark provides some of the strongest purchase incentives, yet electric vehicles make up a relatively small market share there. This may be due to two aspects of the incentive design: company owned electric vehicles receive minimal incentives, and incentives are not available for electric vehicle fleet purchases.

Unlike many other European nations, Germany does not offer substantial electric vehicle purchase incentives and has instead focused on supporting research and development programs (OECD, 2015). Electric vehicle owners, however, are exempt from annual circulation taxes, and company-owned electric vehicles in Germany are eligible for reduced taxes. Due to the higher VAT on electric vehicles compared to their conventional counterpart (due to electric vehicles' greater cost) and a general lack of incentives, electric vehicles in Germany can be more expensive than non-electric alternatives, perhaps explaining the 0.4% sales share.

CHINA'S ELECTRIC VEHICLE INCENTIVES

As discussed above, China provides subsidies and vehicle tax exemptions for electric vehicles at the national level. To further promote electric vehicle uptake, China's national government established electric vehicle pilot cities to financially support electric vehicle development. The five cities in this report, Beijing, Shenzhen, Shanghai, Hefei, and Hangzhou, are part the New Energy Vehicle pilot cities program that began in 2009 (He, 2013). These cities provide local subsidies, as well as other supplementary incentives, in addition to the national incentives to spur electric vehicle sales. As shown in Figure 11, these five markets have shown significant market growth in the past three years and now represent about half of China's 2014 and 2015 electric vehicle sales.

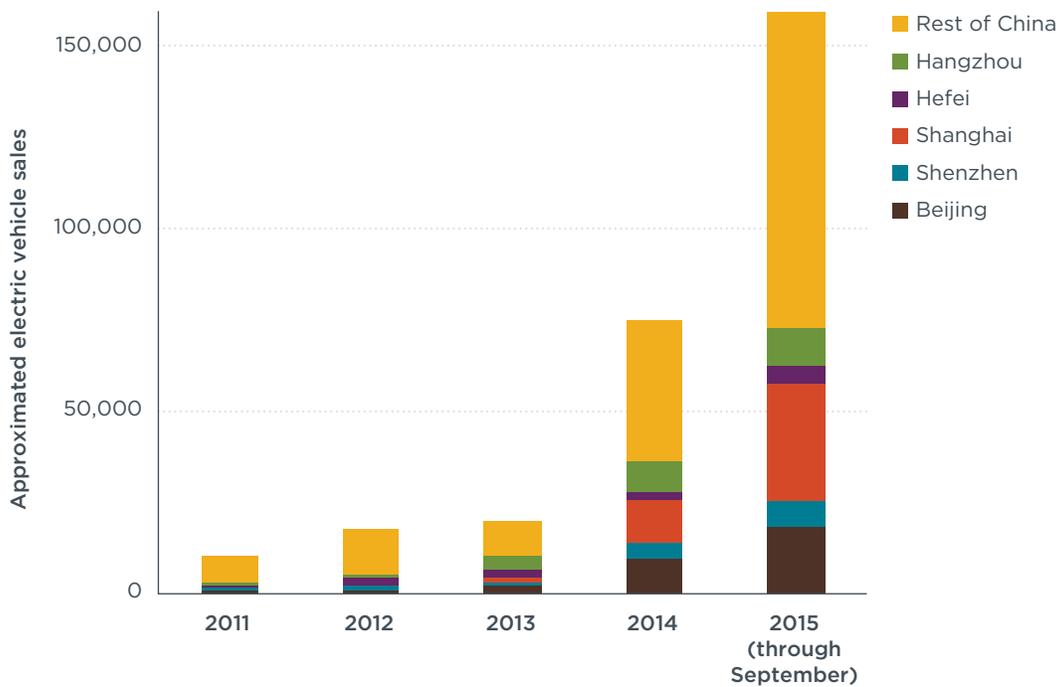


Figure 11. Approximate electric vehicle sales in China by region

Similar to above analyses for the United States and Europe, we examined available data for any link between the electric vehicle incentives and electric vehicle sales shares in China, especially looking at the five pilot cities. Figure 12 shows the estimated total value of incentives for the Nissan Leaf and the Chevrolet Volt (bar chart, right axis) as well as an approximation of the number of electric vehicle sales per thousand vehicle registrations (black line, left axis). Note that electric vehicle sales data is an

approximation based on the best data available; data on electric vehicle sales shares of new vehicles were unavailable. The figure includes the equally applied national government tax reductions applied equally across all five cities, national point-of-sale rebates, and city-specific point-of-sale rebates. The values of subsidies gradually decrease from 2013 to 2015, and the exact values for each vehicle have been made available to the public. This policy design encourages early electric vehicle adoption by providing strong market signals. Shenzhen is the only one of these five cities where electric vehicle subsidies remain consistent in value across the three years, which could partially explain the slower uptake of electric vehicles there. Leasing companies can receive rebates for the purchase of electric vehicles, which will then be reflected in the leasing price for consumers who rent electric vehicles. The vehicle specific subsidies at national or city levels are based on the vehicle category and battery range. PHEVs are required to meet a battery range of 50km to be eligible for subsidies. Beijing is the only city that does not provide subsidies to PHEVs.

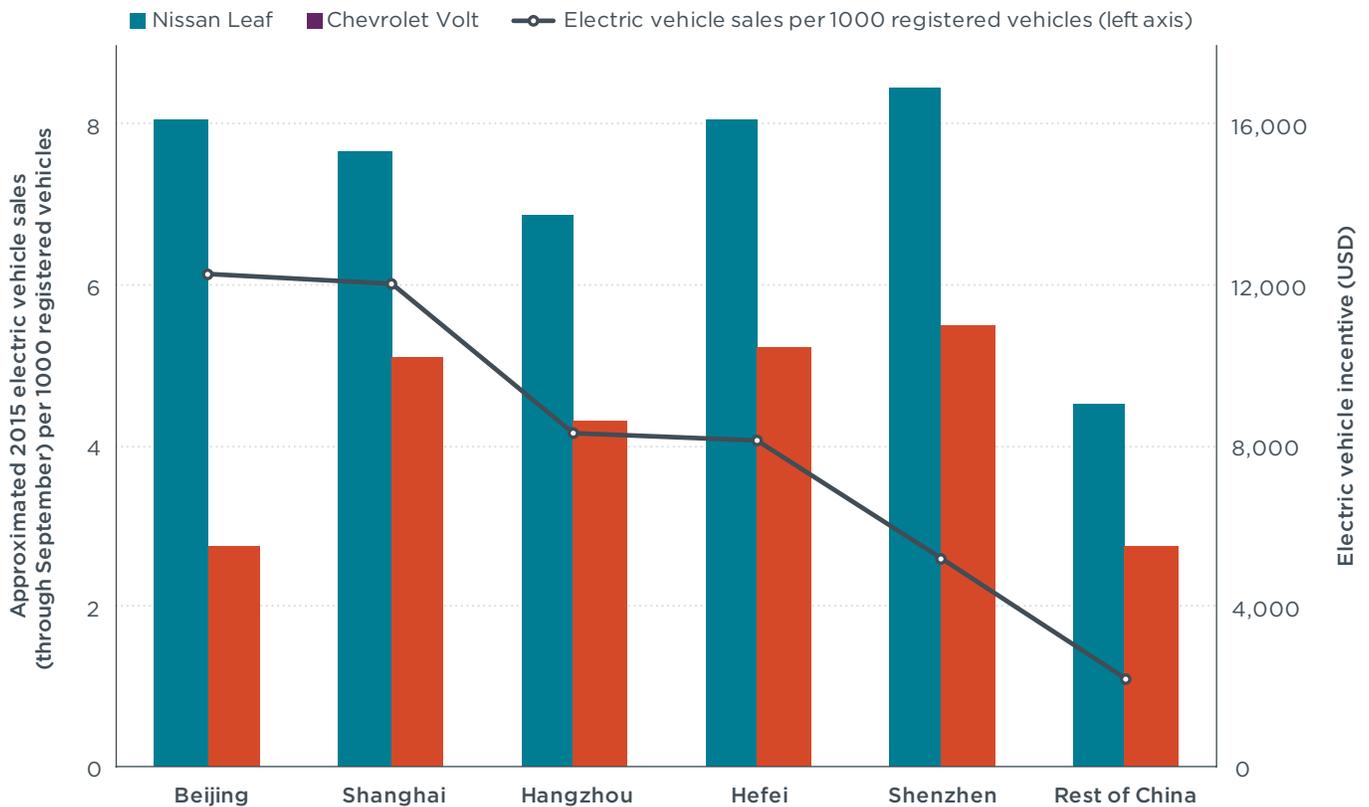


Figure 12. Electric vehicle incentives and approximate 2015 (through September) shares of new vehicles in selected Chinese cities

There are other policies implemented at various levels in China, besides those discussed in this paper, that are important for encouraging electric vehicle uptake at the city level. For example, Beijing exempts electric vehicles from traffic restrictions (conventional vehicles are restricted from the road one day a week). Similarly, Beijing, Shanghai, Shenzhen, and Hangzhou all specifically reduce vehicle purchase and registration restrictions for electric vehicles that otherwise apply to all vehicles. Shanghai, for example, significantly reduces the license plate auction price for electric vehicles; the normal Shanghai license plate auction price for conventional vehicles may be as much as

70,000 RMB (or ~10,000 USD). Shenzhen and Hefei further promote electric vehicles by providing valuable parking benefits.

SUMMARY OF GLOBAL ELECTRIC VEHICLE INCENTIVES

The following two figures bring together data from Section II above on electric vehicle incentives (from Figure 7) and electric vehicle uptake from the various markets to highlight several broader trends from this analysis of electric vehicle incentives. The first figure, Figure 13, shows how electric vehicle shares relate to the relative cost of PHEVs and BEVs, as compared to their conventional counterparts. National and state incentives are both included as applicable for U.S. states in the figure. The figure presents the electric vehicle sales shares (vertical axis), the electric vehicle cost differential from conventional vehicles (horizontal axis), and the approximate annual sales in each of the markets. Basic linear curve fits for BEVs and PHEVs are shown on the figure. The linear regression analysis shows that the relationships between BEV shares and BEV relative cost, and between PHEV shares and PHEV relative cost, are both statistically significant (at p-value less than 0.05). Note that the vertical axis is broken to more clearly show the outlier Norway with all the other data. The BEV relationship shown excludes the Norway outlier (but the relationship was statistically significant with or without Norway). Markets where electric vehicle shares are especially high, as well as where electric vehicles after incentives are especially expensive or inexpensive, are labeled. As illustrated in the figure, the more that electric vehicle incentives offset the price differential and make electric vehicle cost-competitive, the greater electric vehicle share tend to be in markets like Norway, Netherlands, Shanghai, California, Beijing, and Washington. Several markets where electric vehicle prices after taxes and incentives remain high, in markets like Germany and Canadian provinces, are seeing fewer electric vehicle sales.

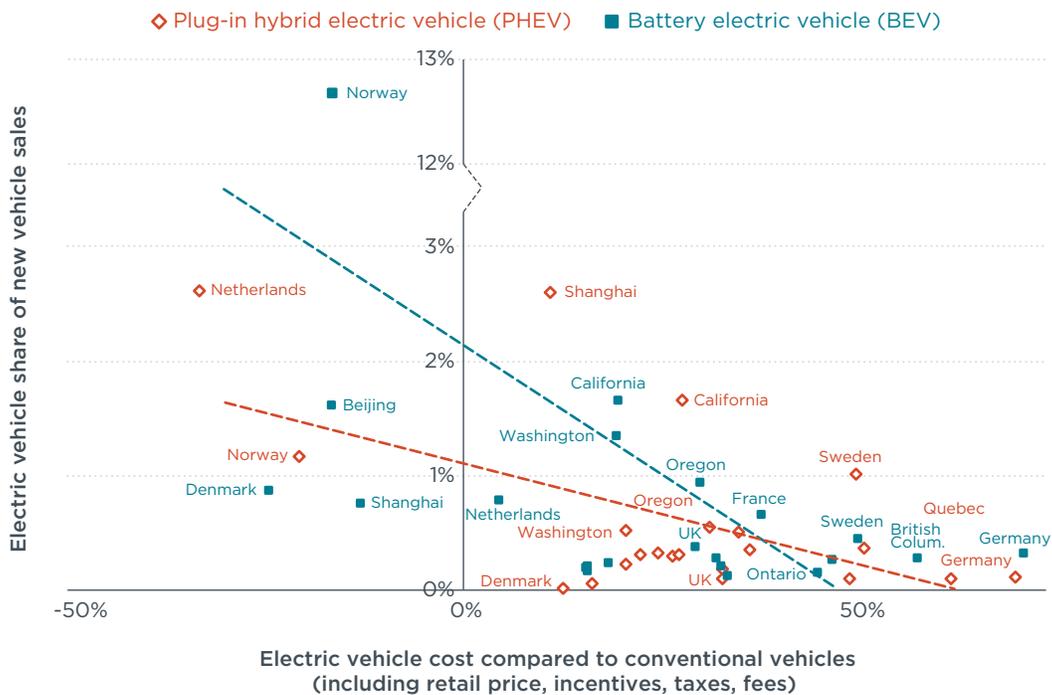


Figure 13. Electric vehicle share of new vehicle sales and average electric vehicle cost difference compared to conventional vehicles

Figure 14 further aggregates the data to provide a simplified summary of the electric vehicle sales shares (vertical axis), the electric vehicle cost differential from conventional vehicles (horizontal axis), and the approximate annual sales in each of the markets. The share and sales numbers in this figure include all electric vehicles, adding BEVs and PHEVs together. The horizontal axis' percent change in price from the conventional vehicle is the simple average from the representative BEV and PHEV data, as analyzed above and shown in Figure 7. This figure shows the additional context of the relative market size in annual sales of the electric vehicles. As highlighted, Norway, the Netherlands, the two China cities of Shanghai and Beijing, California, and the state of Washington have incentives in place that make electric vehicles more comparable in cost to conventional vehicles and are the leading electric vehicle markets. Markets like Oregon and Sweden are emerging, smaller electric vehicle markets, even though their electric vehicle incentives are not as attractive. France, the United Kingdom, and Japan offer a variety of incentives, are major electric vehicle markets by size, but had not seen as much growth in electric vehicle sales shares as of 2014. Similar to above, a statistical regression of these data indicates a statistically significant relationship between relative electric vehicle cost (compared to conventional counterpart) and the electric vehicle share (p-value less than 0.05).

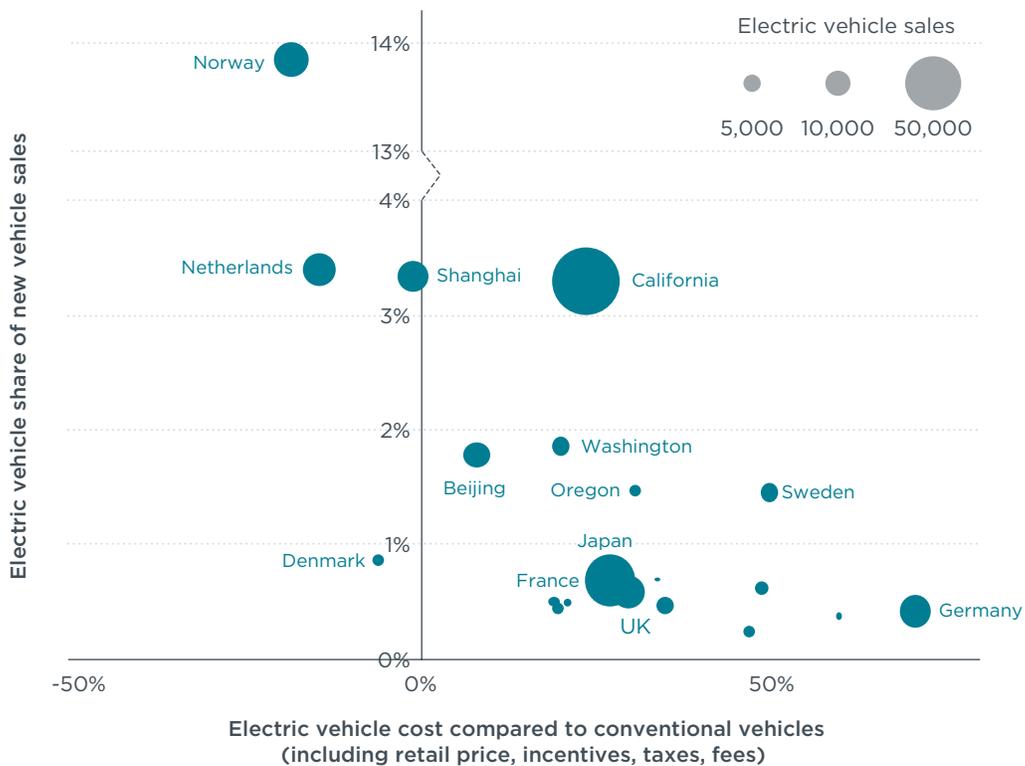


Figure 14. Electric vehicle share of new vehicle sales and average electric vehicle cost difference compared to conventional vehicles

V. CONCLUSION

This research assesses the emerging best practices with the use of incentives to promote the early electric vehicle market development. The analysis investigates the design of electric vehicle fiscal incentives, with a focus on major incentives in place across many major North America, Europe, and China markets. The study catalogues various aspects of electric vehicle incentives, including the magnitude, type, the eligibility by technology type, the timing of the incentive, and the durability of the incentives. The analysis quantifies what incentives are in place, their relative impact on consumers, and investigates global trends that link electric vehicle design to electric vehicle uptake. Different governments emphasize a diverse set of goals in their electric vehicle development efforts, including greenhouse gas emissions, local air quality emissions, fuel savings, and industrial leadership. This work specifically examines incentives' impact on electric vehicle uptake.

Table 3 provides a summary of major electric vehicle markets that exemplify best practices in their electric vehicle incentive programs. Together the ten markets represent over half of global electric vehicle sales in 2014 and they include the leading markets in terms of share of new vehicle sales that are electric. As shown in the figure, these markets all tend to have incentives that are substantial for battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are available close to the point of sale, are offered to leased vehicles, are available for company vehicles, are durably locked into place for at least several years, and are relatively simple for consumers and dealers to understand their value.

Table 3. Summary of selected governments that are exhibiting fiscal electric vehicle incentive best practices

Market	Electric vehicle uptake		Incentive design principles							
	Sales	Share	Substantial BEV	Substantial PHEV	Upfront	Lease	Company	Private	Durable	Simple
	0 50,000	0% 10%								
California			X	X	/	X	X	X	X	X
Japan			X	X	/	X	X	X	X	/
Norway			X	X	X	X	X	X	X	/
Netherlands			X	X	/	X	X	/	/	/
United Kingdom			X	X	X	X	X	/	X	X
France			/	X	X	X	X	X	/	/
Beijing			X	/	X	X	X	X	/	X
Sweden			/	/	/	X	X	X	/	X
Washington			X	X	X	X	X	X	X	/
Denmark			X	X	X	X	/	X	/	/

■ PHEV ■ BEV

NOTES: "X" denotes principle is generally met; "/" denotes principle partially met

In several cases, the incentives in place essentially provide a preview of how the electric vehicle market could grow more broadly when the electric vehicle technology improvements continue to enter the fleet and reduce the vehicle costs in the future. Markets such as Norway, the Netherlands, Shanghai, Beijing, California, and the state of Washington have fiscal incentives in place that make electric vehicles comparable in cost with conventional vehicles (See Figure 13 and Figure 14 above). Electric vehicle shares in these automobile markets, ranging from approximately 2% in Beijing and the state of Washington, up to 14% in Norway, are many times higher than the rest of the world. In 2015 and 2016, electric vehicle sales have continued to increase, especially in these markets. In this analysis we find a significant link between incentives that make electric vehicles more comparable in price to conventional gasoline counterpart vehicles. This finding is especially important because it suggests that electric vehicle technology improvements and associated battery price reductions will allow market growth with reduced incentives over time.

Based on this report's findings, we find that a set of best-practice principles is emerging regarding the design of electric vehicle incentives. The vast majority of electric vehicles are sold in markets with substantial incentives and, in particular, in markets where the incentive design embodies the best principles identified here. The design of the incentive can have a substantial impact for a variety of reasons. Various aspects about the incentives' design affect the total consumer value, the eligibility of consumer, the eligibility of electric vehicle models, and the understandability of the incentive to dealers and consumers alike.

Based on our analysis, we conclude by pointing out the four principles that are emerging as part of the optimal design of electric vehicle incentives:

Move incentives up front to the vehicle purchase and make their value visible to dealers and prospective consumers. A number of incentives have suffered because their value at the time of vehicle transaction is unclear to both the buyer and the seller. Making incentives available at the time of purchase, or shifting the incentives to vehicle purchasing tax exemptions or reductions of similar value, appear to be effective solutions.

Make the value of incentives crystal clear to consumers and dealers. Incentives that have complex indexing of the incentive magnitude—for example, to consumer income, engine size, vehicle emission rates, battery size, or comparable non-electric vehicles—compromise dealer communication and consumer understanding. Simpler incentive programs, which are publicly posted on government websites and distributed to all dealers, would help alleviate this issue.

Ensure the incentives are available to the full target market. Electric vehicles can be an attractive fit in many settings: for company and private cars, government and private company fleets, taxi and car-sharing services, and leases and purchases. When major customers or purchasing options are made ineligible for the incentives, it reduces the effect the incentives can have on driving sales and broadening the exposure of the new technology. Governments can work to remove eligibility constraints to expand the appeal and awareness of electric vehicles to a larger consumer market.

Commit to durable incentives that allow manufacturers, dealers, public outreach campaigns, and consumers to rely on them for at least several years. Prevailing uncertainty over whether incentive programs will be maintained is disruptive and undermines the efforts of industry and prospective consumers. Industry gains from the ability to plan their product placement and strategically market their incentives, and consumers need certainty to weigh their investment. Securing incentive programs for several years—ideally to 2020—is best suited to assist the larger market transition. Within such a framework, governments can still regularly review the incentive policies and, if needed, make adjustments.

Further analysis on electric vehicle incentives will be important in the future. Continuing to improve battery technology and the subsequent reductions in costs will lessen the importance of incentives. A forward-looking analysis of incentives could consider adopting the principles above, in addition to changing the programs to match the new vehicle technologies (e.g., with lower cost and higher range) now entering the marketplace. Such an analysis would ideally include how to optimally taper incentives by 2020 to maintain market growth with reduced government financial support. In addition, although public subsidies and tax reductions for electric vehicles are often substantial, leading evidence to date indicates that major environmental, consumer, and economic benefits tend to greatly outweigh the fiscal costs to governments. Periodic updates on such analyses will help reaffirm that public commitment to electric vehicle support policies remain well justified.

The implications of this research on electric vehicle incentives are broad. Over 500,000 electric vehicles were sold globally in 2015, up from just hundreds in 2010. Most of these electric vehicles were sold in markets where well-designed fiscal incentives are in place. Electric vehicles are likely to be a key part of the transport sector's ability to meet long-term decarbonization goals, so the technology eventually has to meet the needs of the mass consumer market. A key question is how quickly electric vehicles could move beyond this early higher-cost stage to larger volume, greater economies of scale, and lower costs. Until then, optimally designed incentives are bringing the effective cost of electric vehicles closer to those of conventional vehicles, helping to usher in the new electric-drive fleet more rapidly.

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ANNEX

Based on the information collected on the electric vehicle programs being implemented around the world, key elements of the incentives are summarized in Table 4 (for subsidies) and Table 5 (for vehicle tax reductions) in this Annex.

Table 4 summarizes some basic characteristics of subsidies that are implemented in various markets. As shown in the table, most electric vehicle subsidies are offered in the form of rebates, with the exception of the U.S. tax credit, and exemption of France with its feebate system. Subsidies commonly use various systems of minimum requirements and scaling factors to offer differing incentive amounts across electric vehicle models. Several governments provide significant subsidies of \$7,000 to \$10,000 per vehicle, while others offer maximum subsidies of up to \$1,500 to \$2,500 per vehicle. Leased vehicles are eligible to receive subsidies in many regions, but not all. One key difference among incentive programs is the consumer timing; several rebates are provided immediately at the point of sale, while others are received within two to six months of purchase. Importantly, some incentive programs have greater longevity built in, increasing confidence for consumers and dealers that the subsidy can be marketed and utilized throughout the year and over multiple years.

Table 4. Summary of characteristics of electric vehicle subsidies

Region	Type	Minimum requirement	Incentive scaling factor	Max amount (\$)	Lease	Timing of incentive	Change overtime	Funding durability
United States (federal only)	Income tax credit	EV ≥ 5 kWh	Battery capacity	7500	Yes	At end of year when household files taxes	No	At least 200,000 qualifying vehicles per manufacturer have been sold for use
California	Rebate	Meet ZEV definition	Vehicle category, income level	6500	Yes	Upon approval of application within 3 months after purchase	No	Fund availability based on annual budget until 2020+
Connecticut	Rebate	Meet ZEV definition	Battery capacity	3000	Yes	At the point of sale	No	Until \$1,630,000 funding run out
Massachusetts	Rebate	Meet ZEV definition	Vehicle category, battery capacity	2500	Yes	Upon approval of application within 3 months after purchase	No	Since June 2014, \$3.72 million until funding runs out, an additional \$2M approved in April 2015
Maryland	Rebate	Can drive more than 55 mph	Battery capacity	3000	Yes	Upon approval of application, generally takes a few weeks to a few months	No	From July 1, 2014 through June 30, 2017. Subject to funding availability
Ontario	Rebate	—	Battery capacity	5865	Yes	Upon approval of application within 6 months after purchase	No	Since July 1st, 2010
Québec	Rebate	EV≥4kWh	Vehicle category, battery capacity	5520	Yes	At point of purchase	Increased min. kWh	Since January 1 2013 through to the end of 2020
British Columbia	Rebate	EV>4kWh	Vehicle category and battery capacity	3450	Yes	At point of purchase	No	Since April 1, 2015 until March 31, 2018
Japan	Rebate		Price difference between EV and gasoline vehicles	7055	Yes	Upon approval of application	Reduced over years	Since 2012 to 2016, funding periodically renewed
France	Bonus	EV≥10kwh, <110 gCO ₂ /km	CO ₂ emission	7119	Yes	At point of purchase/tax	Reduced over years	Since 2008, with no deadline, renewed annually
Sweden	Rebate	EV≤50 gCO ₂ /km	—	4843	Yes	Upon approval of application	No	Since 2012 until the premium fund runs out
United Kingdom	Rebate	EV≤50g/km and >16km; or ≤75g/km and ≥32km	CO ₂ emission, battery range	7650	Yes	At point of purchase	No	Since 2011, and confirmed until at least 2018. £400M has been made available from 2015 to 2020
China	Rebate	NEV catalog; BEV≥80km; PHEV≥50 km	Vehicle category and battery range	8498	Yes	At point of purchase	Reduced over years	2009 to 2010, 2013 to 2014, 2015 to 2020
Beijing	Rebate	BEV≥80km	Battery range	8498	Yes	At point of purchase	Reduced over years	2013 to 2015
Shenzhen	Rebate	BEV≥80km; PHEV≥50 km	Vehicle category, battery range	9442	Yes	At point of purchase	No	2013 to 2015
Shanghai	Rebate	BEV≥80km; PHEV≥50 km	Vehicle category, battery range	6295	Yes	At point of purchase	Reduced over years	2013 to 2015
Hefei	Rebate	BEV≥80km; PHEV≥50 km	Vehicle category, battery range	8498	Yes	At point of purchase	Reduced over years	2013 to 2015
Hangzhou	Rebate	BEV≥80km; PHEV≥50 km	Vehicle category, battery range	4721	Yes	At point of purchase	Reduced over years	2013 to 2015

Table 5 summarizes some basic characteristics of vehicle tax reductions that are implemented in various markets. Although the details vary, many regions offer both one-time and annual vehicle tax reductions. Vehicle tax reductions commonly use various systems of minimum requirements and scaling factors to offer differing incentive amounts across electric vehicle models. Most regions fully exempt eligible electric vehicles from a certain type of tax, although Japan and Sweden offer partial exemptions. Importantly, incentives apply to leased vehicles in many regions. In European countries, an additional tax is often applied to company vehicles, however company-owned electric vehicles may be eligible for a special company-vehicle tax reduction in some countries. Tax rates tend to differ greatly and are subject to change frequently, thus impacting the value of incentives over time.

Table 5. Summary of characteristics of electric vehicle tax reductions

Region	General tax or VAT	Tax scheme		Timeline
		One-time	Annual	
Norway	25% BEVs exempted	<ul style="list-style-type: none"> Registration tax based on vehicle weight, engine power, nitrogen oxide emissions, and CO₂ emissions. BEVs are exempted. 	<ul style="list-style-type: none"> Circulation tax about 350 EUR 	<ul style="list-style-type: none"> Tax exemption for EVs expired after 50,000 EV sales; government reinstated incentives thru 2017
Netherlands	21%	<ul style="list-style-type: none"> Registration tax based on the CO₂ emission level of the vehicle. BEVs and some PHEVs are exempted. 	<ul style="list-style-type: none"> Circulation tax based on the vehicle weight, fuel type, and CO₂ emission. BEVs and most PHEVs are exempted. [Company car] Income tax based on CO₂ emission EVs have reduction. 	<ul style="list-style-type: none"> Change every 1-2 years. gCO₂/km threshold for PHEV exempted getting lower Tax rate forecast for 1 year ahead
US	7.3% ^a			<ul style="list-style-type: none"> Varied by states, adjusted by states
Canada	16%			
Washington State ^b	8.65% EVs exempted			<ul style="list-style-type: none"> Tax rate varied by cities
France	20%	<ul style="list-style-type: none"> Registration tax based on engine power. EVs are exempted. Malus-bonus tax based on CO₂ emissions 	<ul style="list-style-type: none"> [Company car] Income tax based on CO₂ emission. BEVs and some PHEVs are exempted 	<ul style="list-style-type: none"> Renew tax rate annually
Japan	5%	<ul style="list-style-type: none"> Acquisition tax based on engine displacement and vehicle price. EVs are exempted. 	<ul style="list-style-type: none"> Tonnage tax based on vehicle weight. EVs are exempted Automobile tax based on engine displacement. EVs are exempted 50% 	<ul style="list-style-type: none"> EV exempt is updated/extended periodically, e.g. updated in 2012 and 2015
Sweden	25%		<ul style="list-style-type: none"> Road tax based on CO₂ emission. EVs are exempted. [Company car] Income tax partially based on vehicle price. EVs are exempted 40%. 	<ul style="list-style-type: none"> Tax rate changeable annually
Denmark	25%	<ul style="list-style-type: none"> Registration fee mostly based on vehicle price. EVs weighing less than 2000 kg are exempted. 	<ul style="list-style-type: none"> Annual circulation tax based on fuel consumption. BEVs weighing < 2000 kg are exempted. [Company car] Income tax based on price. 	<ul style="list-style-type: none"> Tax rate changeable annually
Germany	19%		<ul style="list-style-type: none"> Circulation tax based on engine displacement and CO₂ emission. EVs are exempted for 10 years. [Company car] Income tax based on price. EVs have deductions. 	<ul style="list-style-type: none"> Set changeable tax free base margin (2009/2012/2014)
United Kingdom	20%	<ul style="list-style-type: none"> First year excise duty based on the CO₂ emission and vehicle price. BEVs and some PHEVs are exempted. 	<ul style="list-style-type: none"> Excise duty from second year of purchase based on the CO₂ emission and vehicle price. BEVs and some PHEVs are exempted. [Company car] Income tax based on CO₂ emission and price. BEVs are exempted. 	<ul style="list-style-type: none"> Tax rate update every 1-2 years
China	17%	<ul style="list-style-type: none"> Acquisition tax based on vehicle price. EVs are exempted. Excise tax based on vehicle engine displacement and price. 	<ul style="list-style-type: none"> Vehicle and vessels fee based on engine displacement and price. EVs are exempted. 	<ul style="list-style-type: none"> Tax rate is fixed

NOTES: EV = electric vehicle; BEV = battery electric vehicle; PHEV = Plug-in hybrid electric vehicle; VAT = Value-added tax

^a Sales-weighted average of states average combined vehicle sales tax rate.

^b Including state and local taxes